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ABSTRACT

This study developed a variation of the DELPHI approach, a polling technique for systematically soliciting opinions from experts, to produce a technological forecast of developments in the information-processing industry. SEER (System for Event Evaluation and Review) combines the more desirable elements of existing techniques: (1) intuitive (consensus and individual forecasting), (2) trend extrapolation, (3) trend correlation analysis, and (4) normative approach. Application of this approach, oriented toward user requirements, indicated no gaps in hardware technology, but in application of technology to user needs. Four areas to be stressed in total communication, based on all man/machine relationships, are: (1) user satisfaction, (2) standardization of procedures, equipment, software and data elements, (3) the machine as an extension of man, and (4) new organization of machine systems. SEER forecasting permitted the utilization of information not generated by the user and identifies alternatives to facilitate executive decision-making, planning and resource allocation. (AB)

FINAL REPORT

A FIFTEEN-YEAR FORECAST OF INFORMATION-PROCESSING TECHNOLOGY

20 January 1969

Prepared by

Research and Development Division
Naval Supply Systems Command
Washington, D. C.

A FIFTEEN-YEAR FORECAST OF INFORMATION-PROCESSING TECHNOLOGY

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PREFACE

The Naval Supply Systems Command is deeply indebted to each of the individuals and firms who participated in the two SEER panels. Each one of them has added to the knowledge contained in this report and has generously provided the benefit of his time and experience. The author, Mr. G. B. Bernstein (SUP 063B), was ably assisted during the data collection phase by Mr. M. A. Levine (SUP 0631C) and Mrs. K. A. Zierman (SUP 04531A). A special debt is due Mrs. J. M. Sandell (SUP 063C) for attention to the detail and tedious work of manuscript preparation and graphics design.

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CHAPTER I

THE PROBLEM AND APPROACH

A. Introduction

The wisdom of studying the things that shape the future is accepted as proven, even though everyone realizes that predictions about them will lack perfection. Today, one of the most powerful forces in our environment - and at times by far the most important for many firms and even nations - is technology.[1] Once viewed with suspicion in most human institutions, technological change has become the most stable characteristic of modern life. Success in business and efficiency in government demand that management seek new ways of doing things; that planners find new ways to bring ideas together into implementable solutions; and that top management rapidly incorporate these new solutions in daily operations.

Public and private sponsorship has sought to promote invention in an effort to assure a steady stream of improved methods of production and application. During the past quarter century, a vast expenditure of human and economic resources has been invested in research and development. The greater portion of this effort has sought, with marked success, to apply existing knowledge to the solution of operational problems in industry and government. To a remarkable degree, tractable solutions have been generated leading to a more efficient, less costly, and faster ways of doing things once considered to be technically impossible.

[1] James R. Bright, ed., Technological Forecasting for Industry and Government: Methods and Applications (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1968), Preface, p. v.

These huge investments in research and development have prompted management to forecast technology in hopes of being able to monitor and presage technological growth. A lively controversy has developed on the use, methodology, and validity of various technological forecasting techniques. High interest has centered upon intuitive forecasting methods and in particular, the DELPHIC approach. It is generally assumed that the DELPHI technique is merely one method of technological forecasting. Indeed, this is true - but, since it combines the forecasting with the perceived wants or needs of the participants,[2] it is really more than a technological forecast.

The usual forecast attempts to predict what could be - DELPHI tries to predict what will be. DELPHI could be described as an elegant method for developing a consensus;[3] it is a polling technique employed for systematically soliciting the opinions of experts. DELPHI bears deeper investigation because it is directed toward the prediction of the future as it will develop in a situation influenced by many factors beyond the control of the company or agency making the forecast. Its methodology includes the polling of experts representing the controlling factors and from this developing a consensus which can be used in planning. Its advantage consists in the systematic treatment of data that includes the experts' intuitive assessment of related imponderables.

This paper will examine a study conducted by the Research and Development Division, NAVSUP (Naval Supply Systems Command). This study developed

[2] Marvin J. Cetron and Alan Weiser, "Technological Change, Technological Forecasting and Planning R&D - A View from the R&D Manager's Desk," The George Washington Law Review - A Technological Assessment of the Law, Vol. 36, No. 1 (July 1968), p. 35.

[3] Marvin J. Cetron, "Using Technological Forecasts," Science and Technology, No. 79 (July 1968), p. 58.

a variation of the DELPHI approach, SEER (System for Event Evaluation and Review), to produce a technological forecast of what is expected to occur in the information-processing industry. Since any single organization will have only very limited influence on the future decisions and outcomes in an industry, a technique that incorporates the consensus of participant experts should be of inestimable value in planning for the Navy's allocation of research and development resources, as well as other future-oriented requirements.

B. Scope

Many elements of government and industry are concerned with the processing of data and would benefit from the availability of detailed technological forecasts concerning the future direction of the information-processing industry. This paper will study and analyze such areas as: data storage and processing equipment; visual display devices; data reduction and reproduction techniques; remote interrogation; audio, video, and facsimile transmission and receiving equipment; software; pattern recognition; systems and applications; hardware and software standards. The results of these investigations are used to project technological potentials stressing the satisfaction of anticipated user needs over the next 15-year time frame.

C. Approach

Predicting technical advances is dependent upon many unknown variables and at first glance may appear to be a futile task. In this regard, this forecast is designed to consider the probability and general significance of possible future developments. Each potential event is evaluated in terms of three parameters: user desirability, producer feasibility, and probable timing.

The projections included in this study were developed utilizing the SEER technique. It is a combination of the more desirable elements of several existing techniques: (1) intuitive (consensus and individual forecasting), (2) trend extrapolation (simple extrapolation, curve fitting, and curve fitting with judgment modification), (3) trend correlation analysis (precursor events and correlation), and (4) normative approach (goal-oriented).

SEER is made up of two rounds. In Round I, industry was asked to provide a data bank. Approximately 85 innovative firms producing both hardware and software were contacted. On a non-funded basis, they were asked to select several top-level individuals to participate in evaluation of a pre-prepared list of events utilizing the three parameters of user desirability, production feasibility, and probable timing. These people were usually product planners, research and development engineers, and/or production engineers. Each of these participants was asked to add and evaluate additional events related to his particular area of expertise. Round I was basically an application of the intuitive techniques, yet, it permitted the participant to base his comments upon trend extrapolation, trend correlation analysis, as well as other trend monitoring techniques.

Round II was essentially an extension of the Round I results. It served two functions: (1) a delineation of the interactions among the events forecasted and (2) an extension of the state-of-the-art in technological forecasting.

During Round II a group of outstanding experts in information-processing was asked to evaluate the Round I data bank to identify events of importance

and interrelationships between the events. This group was made up of more than 45 of the top names from government, industry, and academia. The non-government experts were provided with token honorariums. Round II was a direct application of the normative approach.

CHAPTER II

PRESENT STATUS

A. Background

The basic requirements for the storage, maintenance, transfer, display, and processing of data may be considered under the following general categories:

- Documents storage, indexing, and retrieval.
- Standardization of data packages, elements, identifiers, formats, hardware, and software.
- Data communication and display.
- Information interface, file generation, format, software, queries, and reporting requirements as related to other systems.

These categories will be discussed and developed from the aspect of the data processing techniques and capabilities currently available for application to the requirement areas specified above. This chapter will stress some opportunities available within today's state-of-the-art. Discussions with Government and equipment vendor personnel indicate that one major constraint impinging upon effective system design is a general lack of awareness of the range and depth of current off-the-shelf capabilities. This problem is accentuated by a shortage of imagination and innovative thinking on the part of system designers and top level management. We design, redesign, and overdesign from the miniscule and extrapolate out to the total system. The result is a hodgepodge network of subsystems tied together in a rather inefficient fashion. This over emphasis on segments of the problem tends to obscure the original purpose

of the system, and invariably results in the organization having to be fitted to the system rather than the system fitting the organization's problem. One of the crying needs in information-processing is imaginative top-level management trained to understand technological potentials, capable of seeing the overall problem and evaluating alternative approaches to the problem.

A comparison of user requirements and current capabilities will be made in order to identify gaps which exist between requirements and technological developments.[1] Consideration will be given to areas where current capabilities are inadequate (require an advancement in the state-of-the-art), adequate, or possibly exceed the requirements. In addition, consideration will be given to cost-effectiveness factors where decisions must be made relative to trade-offs required with respect to advancing the current state-of-the-art. Future developments and projections of anticipated capabilities determined from numerous vendor contacts during the course of this study are provided in Chapter III of this paper.

B. Information Control

1. **Introduction**

The fundamental objective of any information storage and retrieval system, automated or otherwise, is to provide the most rapid access to the complete file of required data, resulting in the acquisition of the information desired within the limitation imposed. It is implied in this objective that requests for information will be satisfied with usable material. One of the most important requirements to place on any selection

[1] NAVSUP R&D bases its comments about current technology upon George B. Bernstein, et al., Technical Data Handling Survey, Vol. I: Review of Projected Navy User Requirements and Current Vendor Capabilities (Los Angeles: Planning Research Corp., 30 August 1967), Appendix B. This data base was updated through visits to vendor facilities, attendance at conferences, and readings in the literature cited in the Bibliography.

or retrieval system is that it yield a high degree of relevant material while excluding selection of the irrelevant.

An equally significant requirement exists for the simplest and most direct procedures available, which will maintain the information file in a current, up-to-date status. New information must be capable of being inserted easily, and old, damaged, or irrelevant information and records should be readily deleted. To insure that the required file deletion and renewal process is performed, definite procedures for operational use must be instituted. One systematic method, particularly useful for hard-copy files, is the maintenance of file utilization statistics which permit realistic consideration to be given to the purging of material. Failure to provide for periodic purging, or the relegation of little-used information to inactive files, will result in the accumulation of "deadwood." Such a policy would increase the scope of file maintenance required, along with a likely increase in material retrieval time.

Although periodic purging will tend to keep file size from increasing at an inordinate rate, the growth of files, as well as changes in user requirements, is to be expected. This implies the consideration of a modular system design which can meet the growing and changing demands of evolutional system requirements. This modular and evolutionary point of view must be borne in mind not only in the specification of procedures, but of equipment as well. In summary, some of the most important overall requirements that must be satisfied to adequately control the information storage and retrieval process are:

- Rapid access to information.
- Capability to select specific information.

- Simplified insertion and deletion of data.
- Provision for current information.
- Provision for usage statistics.
- Modular system design.

2. Storage

One of the major problems facing Government and industry today is the adequate storage of vast amounts of technical data being generated at an ever-increasing rate. This requirement has been evidenced at numerous activities surveyed during this study. Modern technology, in attempting to keep pace with this information explosion, is pressing to advance the state-of-the-art simultaneously on many fronts. As previously mentioned, however, this chapter of the report will be limited to consideration of off-the-shelf capabilities. The following discussion will be primarily concerned with available procedures and resources. Magnetic tape continues as the most universal data processing storage medium, and improvements to its durability and recording characteristics are being made continuously. Tape characteristics and capabilities, already fairly well-known, will not be discussed in this section.

a. Microforms

Considerable effort has been devoted to the development of these media as elements of total information storage and retrieval systems. Equipment is currently available which can convert operational data or technical data to either aperture cards, microfilm, or microfiche with a high degree of resolution. In addition, information which is capable of being exhibited on a CRT or display device can be microfilmed directly from the CRT. Operating at computer speeds, the output, in digital form,

can be translated into alphanumerics. Graphics can also be created by joining line segments under program control. The alphanumerics or graphics can then be photographed directly from the CRT onto 16mm roll film, with options for 35mm or microfiche. Output speeds are stated to be as high as 10,000 pages per hour with input at 90,000 characters per second. Another system with the capability to record data directly from tape to microfilm was recently introduced. For example, a technique for 16mm microfilm can accommodate 20 frames per second, with 64 lines per frame, where each line may contain 132 columns. Coupled with recent increases in reduction ratios, automated microform production may serve as a cost-effective substitute for soft display in many decentralized storage retrieval applications.

Even greater degrees of miniaturization are possible. PCMI (Photo-Chromic Micro-Image), a relatively recent technique, provides a 4- by 6-inch transparency comprised of approximately 3,200 images represented in matrix form. Each transparency can be reproduced for dissemination copies. In this manner, approximately 1 million document pages can be stored in micro-image form on 400 cards, creating a stack less than 6 inches high.

b. Hardware Components

(1) Drums

In the area of random access drum memories which can be used for general or auxiliary storage, systems are currently available with a storage capacity of 3.4×10^8 bits and a maximum access time of 50 milli-seconds. In this system, the read/write heads are in fixed position and are capable of recording or retrieving a single track of digital data from the rotating drum surface. The "flying" head principle (the head rides on a layer of air) is used and the heads never come in contact with the actual

drum surface. Simultaneous read/write access can be provided through four independently positionable channels. Several small drums of this type are currently used on Polaris submarines with good results, although they were not designed for military specification.

Among the larger random access mass storage devices available is the FASTRAND mass storage subsystem. Each unit in the system contains two magnetic drums, and as many as eight units may be connected to an available I/O channel. The total storage capacity is 13×10^6 computer words per unit, or about 65×10^6 characters. All functions of the FASTRAND are buffered from the central processor and the computer can continue processing while records are being accessed on the unit. All read operations are parity-checked and flying read/write heads are also employed in this system. In addition, a rather unique search and read function is featured with the system.

Alternately, smaller types of magnetic drum storage units can provide single drum capacity of 6 million characters, with capability for an additional 6-million-character expansion. The transfer rate is given as 370,000 six-bit characters per second, with an average data access time of 8.5 milliseconds. If desired, dual channels are available for access by two processors.

(2) Disks/Data Cells

One current line of disk files provides modular systems which range from system memory files, having capacities of from 1 to 4 million bytes, to massive bulk storage devices with capacities in billions of characters. Combinations of two or more disk file subsystems are also available and are stated to have a maximum average access time of 60

milliseconds. In addition, system memory units are available as small, fast additions to the computer main memory. Control programs, operating software, and program libraries are stored in system memory and can be accessed as needed.

As another example, modular disk storage units are available which permit the storage of from 8 million to 800 million characters with simultaneous access. Modularity permits storage to be added to increments of 50 million characters. In the largest configurations, there may be 32 disks per unit with four units connected to a single controller. The processor communicates with the controller through one to four processor I/O channels. Four channels may be used for simultaneous read/write operations, attaining an effective character transfer rate of 980KC, with a single channel transfer rate of 300KC. In a random positioning environment, each of 16 independent positioning arms can position in an average time of 90 milliseconds.

Direct access storage facilities are provided by another manufacturer and can store up to 207 million bytes on eight removable disk packs. A single unit provides its own control and has eight independent storage drives. As many as eight units can be attached to each of six selector channels on the mainframe. Nearly 10 billion bytes can be on-line at one time. Average access time is given as 75 milliseconds. Multiple records can be read and written by a sequence of channel commands, with no rotational delay between records. In addition, a data cell drive is also available which provides a solution to the storage of large, sequentially organized data files requiring random reference. Ten data cells, each with a capacity of 40 million bytes, provide a 400-million-byte capacity for each data cell drive. Up to eight drives may be attached to a single

storage control unit for a total direct access capability of more than 3 billion bytes. Each of the 10 data cells is removable and interchangeable so that off-line storage capacity is virtually unlimited.

3. Indexing

Independent of the manual or automated techniques employed for the storage of information, detailed procedures are also required for indexing the material stored. The indexing procedure may be generally described by two basic steps:

- Specifying terms which identify the item for the purpose of later retrieval.
- Associating the identifying mark with the item itself and/or recording on a separate item substitute the tags or labels representing these items.

The first step in indexing depends on the capability to determine the informational categories which are meaningful to the user. The degree to which these are correctly resolved will determine the utility of the system. The second step is more routine or clerical in nature. Whether the indexing identifier is recorded on the item itself, or recorded in a separate table or catalog with a means of translation for actual item location, is dependent on the retrieval technique and devices used.

Associating the index directly with the items and searching the items directly has the advantage of the simultaneity of item identification and actual item selection. Search speed, flexibility, and item accounting capability can often be increased, however, if the search process is carried out independently of the actual items, particularly if a computer is employed. Consideration of the particular attributes possessed by each

of these techniques and the devices available for their implementation form a significant segment of the alternative selection and cost/benefit analysis efforts of a design study.

The logging, summarization, and coding of each item in a log and/or file catalog is necessary for item accounting, as well as for item retrieval if the item file catalog serves as the item table for the retrieval process. In all cases, the log and/or file catalog serves as the source of information on the current content of the complete item file.

The assignment of the physical storage location for an item could be made either directly from the item index assignment, independently of the index assignment, or indirectly from the index assignment by means of a translation function relating the index of the item to a specific physical storage location. Again, the particular attributes offered by each of these possibilities, and the devices available for their application, must be evaluated in a design study.

With respect to some of the indexing schemes employed in the microform areas previously discussed, the MIRACODE (Microfilm Information Retrieval Access Code) system is an automatic file, storage, and retrieval system using microfilm as the storage media. Documents are identified by assigned numbers and/or descriptive keywords. As the source information is being processed, either from aperture cards or CRT, the equipment automatically generates the MIRACODE indexing format on the microfilm. The source document can then be retrieved by the characteristics or numbers assigned in the MIRACODE system.

4. Retrieval

Information is usually retrieved in response to a user query. Query requests can be initiated for a single item, a general category of items,

or for particular items and/or categories or items suggested by a previous query response. In any case, the coding of the item or categories requested, utilizing some form of indexing previously mentioned, is necessary before item retrieval can occur. As mentioned earlier, the search for the item identifiers matching the codes requests or queries can be accomplished by searching a catalog file of the items or by searching the items themselves.

Some of the microform retrieval systems currently available are the MIRACODE and PCMI systems. For system automation requiring the storage and retrieval of millions of document pages, the PCMI systems contains a computer-driven file and viewer. In this system, a search can be initiated with the computer for documents matching specific search parameters. When a match occurs, the document location is transmitted to the system for automatic retrieval of the card and automatic positioning of the viewer.

Viewers currently available provide for the enlargement of the micro-image to the approximate size of the original document for screen viewing. Additionally, where desired, a full-size hard-copy printout and/or standard microfilm (16 mm or 35 mm) of the micro-image may be obtained.

A different type of system is the SELECTRIEVER, a random access retreival system which can accommodate up to 200,000 individual documents of EAM card size (3-1/4 by 7-3/8 inches). The documents may be either aperture, microfiche, or ordinary cards with information written on them. The methodology for access is based on notches along the bottom edge of the card. In a maximum of 10 seconds, the SELECTRIEVER can access of specific document, present it to the operator, display it, or prepare a hard copy of the information. Average access time is 6.5 seconds. The SD 500 is a device with a similar purpose, but operates on a different

card selection principle. The CARD system offers similar capabilities in a much simpler, less costly, but lower capacity device.

Mass memories are another example of large-capacity, high-speed, random access information storage and retrieval systems which can be used in conjunction with existing data processing systems. One type of mass memory consists of two principal elements: a mass memory unit to provide data storage; and a controller unit that provides the necessary interface, control, and read/write functions. In this system, the technique of information retrieval is either fixed-address-search or search-by-record-content, depending on the master control used. Average access time is 35 milliseconds. Search-by-record-content is a specialized technique which permits any desired field to be used as the access key. It is not necessary to know where the data are stored, but only what type of data is desired. This obviates the need for flagging and table look-up, conserves space in the CPU mainframe memory, and allows for simultaneous off-line search.

C. Standardization

1. Introduction

Historically, efforts in the field of standardization were greatly enhanced in 1964 by two important events:

- Establishment of the DOD Council on Technical Data and Standardization Policy.
- Promulgation of DOD Directive 5000.11 establishing the DOD Data Elements and Data Codes Standardization Program.

Within the purview of the Council is the authority to approve and initiate major standardization projects. The stated objective of the Data

Element and Data Codes Standardization Program is to facilitate data interchange and compatibility among the data systems of DOD by providing for optimum standardization of data elements and codes and for their utilization, through centralized guidance, control, and direction.

Additionally, the utilization of standardized data elements in the overall Navy Component/Equipment Standardization and Configuration Management Programs will be discussed. Specific areas of application will be identified and several possible files and lists utilizing standardized data elements will be mentioned.

2. Data Elements/Codes

Standardization of data elements and codes will:

- Facilitate interchange and compatibility of data among different ADP systems and DOD agencies.
- Reduce the total number of data elements and codes.
- Reduce data processing costs by using standard codes in lieu of full data descriptors.
- Facilitate the development of standard information and data systems by standardizing the data elements and codes which are system building blocks.
- Facilitate integration of systems and direct computer-to-computer communication.

The capability and expertise currently exist to identify, define and systematically record informational elements now used in vocabulary formats suitable for maintenance by the office or agency having primary functional interest. These vocabulary formats would be capable of accommodating both automated and manual maintenance, be susceptible for use in standardizing

informational elements and codes, and permit series grouping in order to form a complete vocabulary of operational and management data bases.

In the initial identification of informational elements, criteria and procedures which may be useful in developing recommendations for standard data elements and codes include:

- Is the data element limited to a single generic class of data?
- Is the data element name or title unique?
- Does the data element have a single, precise definition?
- Is each data item under a given data element mutually exclusive?
- Does each data element have a set of data items which is different from those of any other data element?
- Does the code assigned to each data item under a data element accommodate all known requirements for use of the code?
- Is it necessary to use any data element and its associated data items more than once within a given data system?
- Is each bit of information within a data code significant?
- Does each significant bit actually denote something different from all other significant bits used in other codes?

A discussion of significant criteria can extend almost *ad infinitum*. As an example of the consideration given to the first question listed above, if more than a single class of data is represented in combination, then more than one unique data element exists and should be established. The FSN (Federal Stock Number) is a prime example; it is composed of at least three generic classes (*viz*., Federal Supply Group, Federal Stock Class, and Federal Item Identification).

In addition to establishing the criteria for the identification of data elements, it is also necessary to determine descriptors for those information elements that constitute the system data base. Examples of these descriptors are element name, brief description, length and characteristics of any data codes used, name(s) of systems which use the element, security, classification according to DOD (or other) data standardization terminology, etc.

3. Equipage

Technical data are, in themselves, the primary means for the communication of instructions, plans, and descriptions relating to technical projects, material, and systems. This data may encompass specifications, standards, engineering drawings, lists, etc., and may be in the form of documents, displays, EAM cards, or magnetic tape. When these data are applied and used in a systematic and orderly manner, following a well-defined series of steps and decision rules to produce definite design decisions, then the configuration identification aspect of the total configuration management task has been established.

The NAVLOGSIP (Navy Logistic Support Improvement Plan) contains objectives related significantly to standardization configuration management.[2] These include increasing the standardization of ship types and equipment and a plan for configuration control. Standardization planning will provide for: (1) the use of a minimum number of sizes, types, varieties, and kinds of components and equipments, and parts, and (2) the use of identical components and equipments wherever complete

[2] Navy Logistic Support Task Force, Navy Logistic Support Plan, June 1965, p. iv.

functional interchangeability exists. Standardized component/equipments will be included and controlled in master configuration listings and indices. The overall Configuration Management Plan will include procedures and criteria for a thorough evaluation and demonstration of the cost-effectiveness of proposed engineering changes, alterations, or improvements. The Navy Configuration Management Program provides for the development and maintenance of uniform policies, procedures, and implementing instructions for the attainment of these objectives.

The extension and utilization of standardized technical data elements and codes in the overall Navy Component/Equipment Standardization and Configuration Management Program are immediate. Lists of standardized data elements can be utilized in the determination and identification of common types of components and/or those components and equipments which may be functionally interchangeable. Combined with costing data elements and operational or reliability characteristics, (which may possibly be provided by the Navy 3M (Materials Maintenance Management) system utilizing the MDCS (Maintenancs Data Collection System), a priority or preference list of components could be determined with respect to the cost-effectiveness factors involved. Components which have only one or two functional applications may possibly be replaced by those having greater utility. Moreover, various standardized catalog files can be produced based upon the standardized parts and components information determined.

D. Data Communications

1. Introduction

In a survey conducted at several Navy activities,[3] a number of requirements were highlighted which could receive some degree of satisfaction

[3] [illegible]stein, op. cit., Chapter II and Appendix A.

through the utilization of data communication products now available. Requirements relating to the data communication area can be generally categorized as follows:

- Faster response time.
- Real time capability.
- Data transfer compatibility.
- Centralized data banks.
- Improved inputting techniques.
- Interrogation capability.
- Remote inquiry capability.
- Improved means of transferring data.

The remainder of this chapter will discuss some of the currently available data communication products which could be considered in meeting some of the aforementioned requirements.

2. <u>Remote Terminal Devices</u>

Remote terminal devices may be divided into two major categories, manually operated devices and higher speed devices. As is generally the case, certain devices overlap into both categories.

a. <u>Manually Operated Devices</u>

(1) <u>Numeric Devices</u>

One form of data input that is growing in popularity is the numeric keyboard device, often coupled with a form of card reader. A good example is IBM's 1001, which has a punched card reader and a 10-key keyboard. The 1001 operates at 12 digits per second over leased lines or over the voice grade dial network using a data set. It is possible to transmit alphabetic information from the card, but the keyboard is limited to numeric data.

A similar type of operation can be achieved with Bell System's new touch-tone telephone. This device can be a simple 10-key keyboard, or a plastic card reader utilizing the cards that are used in card dialing, or can be easily punched with a stylus. Fixed numeric data can be punched into a plastic card, and variable data can be entered via the keyboard.

Bolt, Beranek and Neuman, Inc., Cambridge, Massachusetts, has developed a system that provided two-way communication with a computer using ordinary dial telephones and requiring no additional attachments. After the connection has been dialed, the dial is then utilized for data input.

IBM offers "programmed keyboard" models 1092 and 1093 that can provide a means of manual input. The 1092 has a 10 x 15 (or optionally 10 x 16) array of buttons; each column has 10 buttons for the digits 0 to 9, and there are 15 to 16 columns. The buttons need not be limited to digits, however, as "Keymat" overlays may be laid over the keyboard so as to give coded meaning to the keys. For example, each of the 10 keys in one column can represent a different type of transaction. One model of the 1092 has a sensing device attached to the keyboard which allows the computer to know which overlay is being used. The 1093 is a similar device with a 10 x 10 array. It can be used by itself or with a 1092 so as to handle up to 26 columns of data.

(2) Alphanumeric Devices

The most widely used input devices in this category are the teletypewriter units offered by Teletype Corp., Western Union, and Kleinschmidt. The general range of speed is 60 to 100 words per minute. However, there are a number of small differences in transmission speeds,

character coding, etc. In the past, most of these devices have used a five-level code (generally the Baudot code); now, however, the use of an eight-level ASCII code (seven information bits plus a parity bit) has come into vogue. A major advantage of teletypewriter devices is that they are currently available and relatively inexpensive.

Another form of alphanumeric device is the all-purpose communications console. IBM produces such a device called the 1050, and Honeywell offers a similar device which they call their Multipurpose Console. These devices offer a typewriter keyboard, printer (similar to a typewriter printer, but independent of the keyboard), card reader and punch, punched paper tape reader and punch, and control circuitry. Since most of these features are optional, the user may select those he desires. The IBM 1050 also permits the use of a 1092 or 1093 programmed keyboard. The Honeywell Console allows the use of a unique optical scanner (for reading bar code).

The IBM 2740 and 2741 are Selectric typewriters with standard keyboard, upper and lower case. The 2740 can operate on a party line hookup, while the 2741 requires a private line. The terminal can be used as a regular typewriter or can be used to transmit and receive data. Also, the terminal can communicate with other similar terminals or with an IBM 360.

b. Higher Speed Devices

Higher speed devices can be used as I/O terminals connected to a central computer, or as the terminals in point-to-point communication links. Punched paper tape readers and punches operate in the general range of seven to 100 characters per second, depending on the particular devices and the transmission speed of the communication channel. The devices are offered by Digitronics, AT&T, Teletype Corporation, Western Union, General

Electric, and Friden and Tally. For bidirectional communication, a reader and a punch are required at each terminal.

Punched card readers and punches can be used as remote terminals to achieve transmission speeds higher than manual keying speeds. Transmission usually is via voice grade lines, with speeds of 100 to 300 characters per second. Manufacturers include IBM, Digitronics, and UNIVAC.

Some communication channels have been set up with punched paper tape or punched card readers at the remote terminals, and with magnetic tape units at the central receiving point. With such systems, the speed of transmission is limited by the slower remote unit, usually in the range of 100 to 300 characters per second. However, if transmission is between two magnetic tape units, or between a computer and a remote tape unit, transmission speeds can be much higher, depending on the capacity of the communication line. For instance, available systems can transmit up to 5,100 characters per second (peak speed) using TELPAC A, or up to 60,000 characters per second using TELPAC D. Manufacturers include IBM and Digitronics.

The main trust currently visable in the computer industry is in the area of data acquisition. Viatron is offering computing capability to even the smallest user through a micro-programmed terminal that rents for $39/month. Such a device might have an interesting application at the Navy's non-reporting supply activities. Energy Conversion claims to have an invention that could lead to tubeless television and micro-miniaturization ten times greater than the silicon chip technique currently in use. Electronic Data Systems Corp. talks about a $20/month terminal (powered by batteries) which can be connected to a computer

through an ordinary telephone. A potential use for such a device in the Navy Supply System would be to provide ready access to inventory levels, shipping dates, and unit price information. The most recent addition to the ultra-low priced terminal market is Honeywell's COM-PACT. This device is only nine inches square and two inches think, weighs six pounds, and rents for $14-$16/month. Chapter III makes reference to the development of a Dick Tracy-like two-way wrist radio-TV sender-receiver. Developments such as these make one wonder just how close to fruition such a device might be.

3. Fast Response Systems

With the advent of the third generation computers and advancements in data communication products, the capability now exists for exploiting fast response systems (i.e., systems aimed at providing a rapid computer service). This type of system is sometimes referred to as real-time and online. The surveys previously referred to invariably elicited the comment, "A more rapid response is required." The remainder of this subsection will be devoted to some recent developments in fast response systems.

a. Time-Shared Systems

Time-shared systems are aimed at the question, "How can a fast response computer service be provided to a large number of users?" In essence, time-shared systems commutate a large central computer among a number of users so as to provide fast access and response for each user on an economical basis. By simultaneously sharing the central computer and its powerful software features among a group of users, the cost to each user is kept at a reasonable rate. Further, input to and output from the computer is provided by a terminal located at the user's site,

connected to the computer by electrical transmission. Thus, a time-shared system consists of the combination of the computer, communications facilities, local I/O units, and a specially designed software system.

The emphasis in time-shared systems is service to the user. Service is considered to be more important than the highly efficient use of the computer. Expressed another way, faster service to the individual user is achieved at the expense of greater computer running time and memory size than might be required to do the same group of jobs on a batch basis. Time-sharing reduces turnaround in the following ways:

- Queue time waiting for the job to be keypunched.
- Messenger time to and from the computer.
- Queue time waiting for the cards to be put into the computer card reader and read into the computer, including operator inefficiencies.
- Queue of jobs in the computer, waiting to be executed, in a compute-till-complete system. In a time-shared system, each job is worked on for at least one "time slice" every few seconds, and often only one or two time slices are needed to begin producing responses to the users.
- Mass printing needed to answer all the questions the user may ask. With a time-shared system, only the specifically desired information is printed-out on the remote console.

Some important goals of time-shared systems are:

- Improve communications between the user and the computer by the use of powerful software packages.
- Edit the input for errors as it is entered, and notify the user of these errors immediately.

- Aid the user in trial-and-error problem solving.
- Improve utilization of the computer by using "background jobs."

b. Types of Time-Shared Systems

Not all time-shared systems adopt all of the above goals, nor do they always approach the achievement of a specific goal in the same way. Their differences appear to be due to the different environments in which the systems were developed and the points of view adopted by those who developed them.

Some approaches to time-shared systems concern the use of time slices. The microslice philosophy is aimed at providing each user with at least one time slice of computing within 1 or 2 seconds, thus maintaining a "conversational mode" between the user and the computer.

One approach to the time-sharing systems concerns the language that is used to communicate with the system. Some systems communicate via machine-oriented languages, while others communicate via user-oriented languages. Another approach has been the scheduled time of operation for the time-shared systems. Some systems operate practically full-time in the time-shared mode, while others are used only part-time for time-shared activities, with the remainder of the time used for batch processing.

4. Multiprogramming

Multiprogramming is one of the means by which a capability is provided for achieving fast response systems (see previous subsection). Multiprogramming is the concurrent processing of independent programs by a single processing unit, through the overlapping or interweaving of their execution. One feature of multiprogramming is that the programs should be written with no assumption of interaction between them;

thus, one program would not periodically interrogate another program to see if control should be transferred. In a multiprogramming enviornment, programs can be run either serially or in a concurrent mode, with no changes in the programs. The goal of multiprogramming is to provide better computing service and to improve equipment utilization by making use of machine idle time.

In fast response systems, such as time-shared systems and real-time systems, where the total message service time might be compared with the arrival rate, multiprogramming plays a key role. Much of the total service time is consumed in retrieving and storing both programs and data in mass storage units. Through the use of multiprogramming, when one program initiates an I/O request, control is transferred to another program which is ready for processing. The result is that these systems can service a much larger volume of messages within the time limitations than would otherwise be the case.

Multiprogramming is a fundamental component of a time-shared system. It has reached a stage of development where it is well within the state-of-the-art.

E. Generalized File Processing Software

1. Introduction

One method of meeting or satisfying some of the technical data processing requirements may be the more prevalent use of generalized file processing software. Such systems offer a means for converting applications to a computer with much less programming effort than is required by conventional programming methods. This increases the probability that more data may be in machine readable form, and may consequently result in a reduction in manual efforts.

These systems perform most or all of the common file processing functions of file creation, maintenance, sorting, selection, extraction, and report preparation. Equally important, they provide a structure for the solution of file processing problems; that is, they give the systems analyst-programmer a start toward the solution of a problem.

There are three major types of generalized file processing software which are similar in many ways, differing more in degree than in concept. They are the generalized programs, file management systems, and select-extract-report systems.

2. Generalized Programs

Generalized programs ordinarily entail the development of basic data processing functions. These functions are usually well-defined and include sort, merge, extract, file, update, match, and summarize. Several of the functions may be linked together in one computer run.

3. File Management Systems

File management systems differ from generalized programs in that they use broader functions. For instance, a file management system might consist of five basic functions: file creation, file maintenance, select-extract, sort, and report. File maintenance in such systems consists mostly of the insertion, deletion, and replacement of records in a file or fields in a record. Limited computation, such as adding transaction amounts to file summary amounts, might be performed in posting transactions to a file. If complex logic is needed to control such posting, or if the calculations are lengthy, these systems provide standard exits for "own coding." A fair amount of logic and arithmetic capability is usually provided in the report function for developing multilevels of

controls. Another characteristic of these programs is that retrieval requests are designed so that they can be filled out by persons who know their problems and who normally are not programmer personnel.

4. Select-Extract-Report Systems

Select-extract-report systems are really a subset of the file management systems. They do not perform the functions of file creation or file maintenance; however, they do provide easy, flexible data retrieval services from existing files. Such systems usually are limited to a fixed-length record and to little or no computation.

F. Conclusions

Improvements can and should be made in data handling. However, although such improvements could be made, this fact does not denote that there exist gaps between available equipments and technical data processing requirements. In fact, with possibly only a few exceptions (i.e., the input and communications areas), it appears that there are sufficient equipments presently available to handle all observed data processing requirements.

Substantial gaps do exist in the area of uniformity in equipments and procedures. For example, individual Navy activities often have widely divergent equipments to perform identical tasks, with consequent inefficiencies resulting from duplication, time-lag, syntax errors, and logical errors. Therefore, it is concluded that any gaps that do exist (with the exception of input and communications equipment) lie in the realm of system procedures, rather than in the realm of equipment.

Current and proposed improvements in equipment for data processing tend to point to more efficient utilization of the type of equipment

currently available. Little in the way of new, revolutionary equipment that "will be the answer to all problems" is being contemplated. Again, the exception concerns the input and communications areas, where significant improvement must be made (e.g., optical scanners and high-speed modems).

In summary, the major gaps that were detected during the conduct of this study were primarily in the realm of (1) lack of uniformity in systems and procedures, and (2) lack of uniformity in equipment.

G. Some Sample Applications

1. Introduction

Since information-processing technology impacts on a wide variety of functional areas within Navy, it would be impossible to cite examples of how future technology would affect the entire spectrum. However, in order to demonstrate how future technology can be considered in system design decisions, examples of three generalized approaches for handling technical data have been developed.

Prior to proceeding with the description of possible data handling systems, definitions will be provided for centralized, decentralized and combination centralized/decentralized systems. Centralized data processing systems satisfy data processing requirements for separate organizational units at a common computer center. Decentralized data handling systems are self-contained in an organizational unit. A centralized/decentralized system is a combination of both types. A technical data handling system would perform processing functions common to all organizational facilities (e.g., maintenance of all drawings) and also the facility would have a capability to satisfy its own unique requirements.

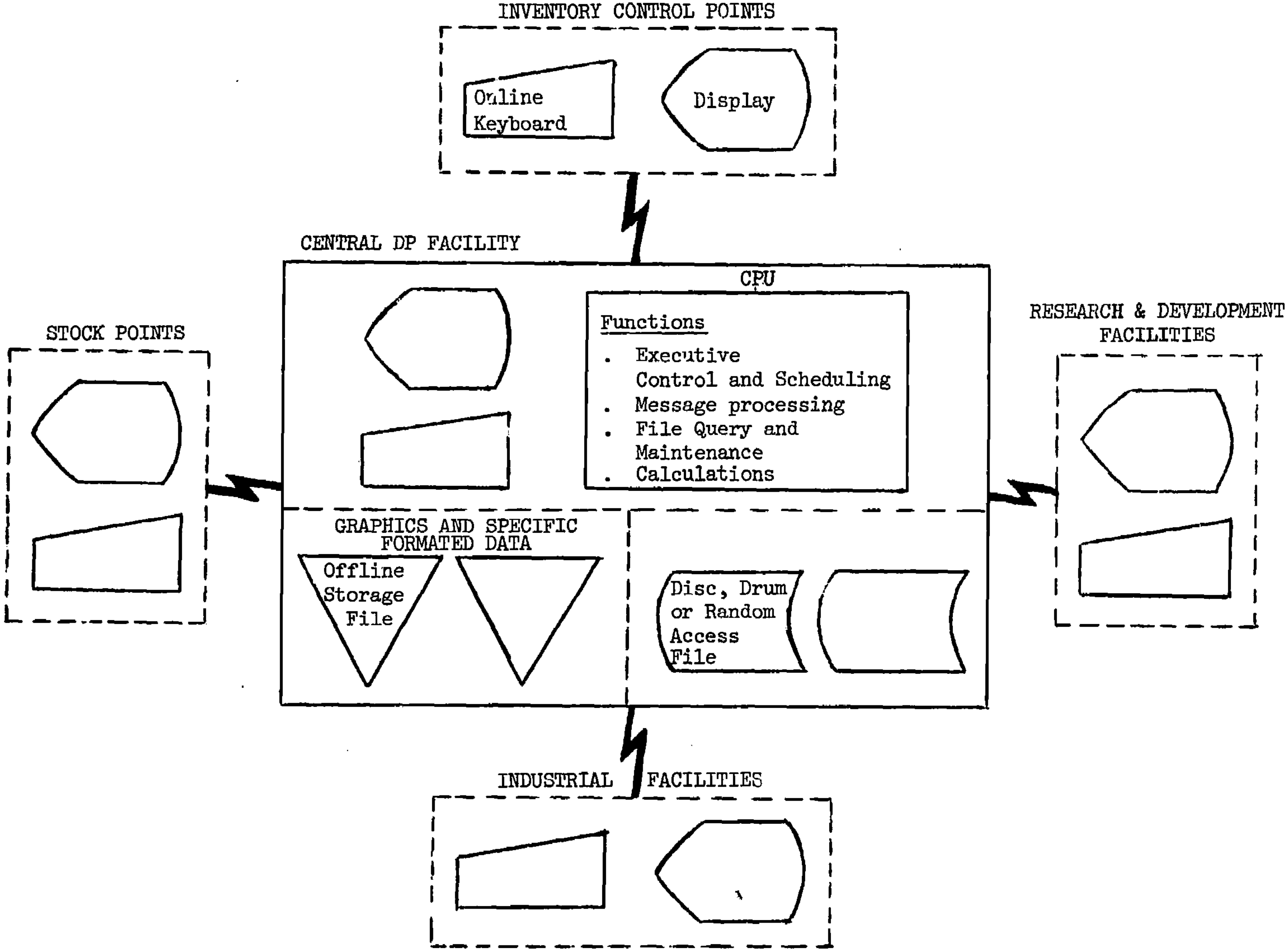


EXHIBIT 1 - SCHEMATIC OF A CENTRALIZED TECHNICAL DATA HANDLING SYSTEM

2. Centralized Technical Data Handling System

A possible centralized data handling system configuration is presented in Exhibit 1. The system envisioned in the Exhibit would perform all technical data handling for each organizational facility and transmit the processed information in a suitable format to the facility via communications links. Remote terminals at each facility could either display formated data or graphics, with a capability to produce hard copy as required. Each facility would query this central file to satisfy the bulk of its requirements for technical data. The central processing unit or processors would perform the following functions:

- Executive control and scheduling of all processes to be performed for all users.
- Message processing, that is, the handling of incoming requests from remote locations and message generation to be retransmitted to the appropriate user.
- File query and maintenance, which includes the retrieval of data elements from the data base and/or referencing the exact locations of documents or drawings located in an offline storage.
- Calculations which are involved in the generation of summary reports.

If a centralized data handling system were used, there would be a requirement for an enormous data base for storage of both digital and graphic data. Without a detailed study of the volume and variety of the required data base, the appropriate type of storage media can only be postulated. An offline capability would be required to store engineering drawings and other documents which require infrequent access

since it is both exorbitantly expensive and inefficient to digitize this data and store it in auxiliary online memory. With the current R&D developments in data storage devices, and the fact that the trend is towards microforms these offline storage devices will probably be some type of microform (e.g., microfilm, microfiche, or holographic memories). The system would undoubtedly contain formated files such as parts lists, etc., which would be stored and maintained in a mass memory device such as disk, drums, or random access files. This device could be used to store a portion of the data base which requires frequest access as well as indices for retireving data or documentation maintained in offline storage.

3. Decentralized Technical Data Handling System

In a decentralized technical data handling system each facility has its own data processing capability. All of the functions that were listed in the proceeding section for a centralized system would be accomplished at each organizational facility. If a decentralized system were to be used, much of the common processing still should be standardized among the facilities. The diversified functions of a research and development facility might require both information retrieval capability and high level scientific processing capability due to projects such as Computer Aided Ship Design.[4]

4. Centralized/Decentralized Technical Data Handling System

A centralized/decentralized technical data handling system would imply that specific requirements (e.g., centralized drawing file) common

[4] Bernard W. Romberg, CASDOS: A System for the Computer Aided Structural Detailing of Ships -- Present Status, A Symposium held by the Chesapeake and Hampton Roads Section of the Society of Naval Architects and Marine Engineers, September 1968.

to all facilities would be fulfilled by a central computer facility and each organizational unit would have a technical data processing capability to perform its own unique functions. For example: All requests for data pertaining to parts lists and parts descriptions could be handled by a central facility. In addition, a central repository of engineering drawings pertaining to a particular installation might be maintained locally. An example of a unique processing requirement would be the effort of Computer Aided Ship Design being carried on at a research and development activity since it has requirements for scientific calculations and computing equipment may be entirely different than that of the central facility which would be more of an information handling system. A diagram of a possible technical data handling system configuration is presented in Exhibit 2.

A centralized/decentralized system, as depicted in the Exhibit, would have the advantage of allowing for a more efficient design of a retrieval and indexing system for access to formated data and the large number of drawings required by various operational units. That is, each of the facilities could have their own file pertaining to active drawings and formated data according to their area of interest. This would permit each facility to use a more detailed retrieval system pertaining to the small volume of active drawings it would have to maintain. Then the centralized facility could maintain the complete set of drawings in both hard copy form and the microforms, utilizing a computer indexing system. Since this file would contain the relatively inactive drawings of many facilities, it would be feasible to provide a retrieval system which could handle a large

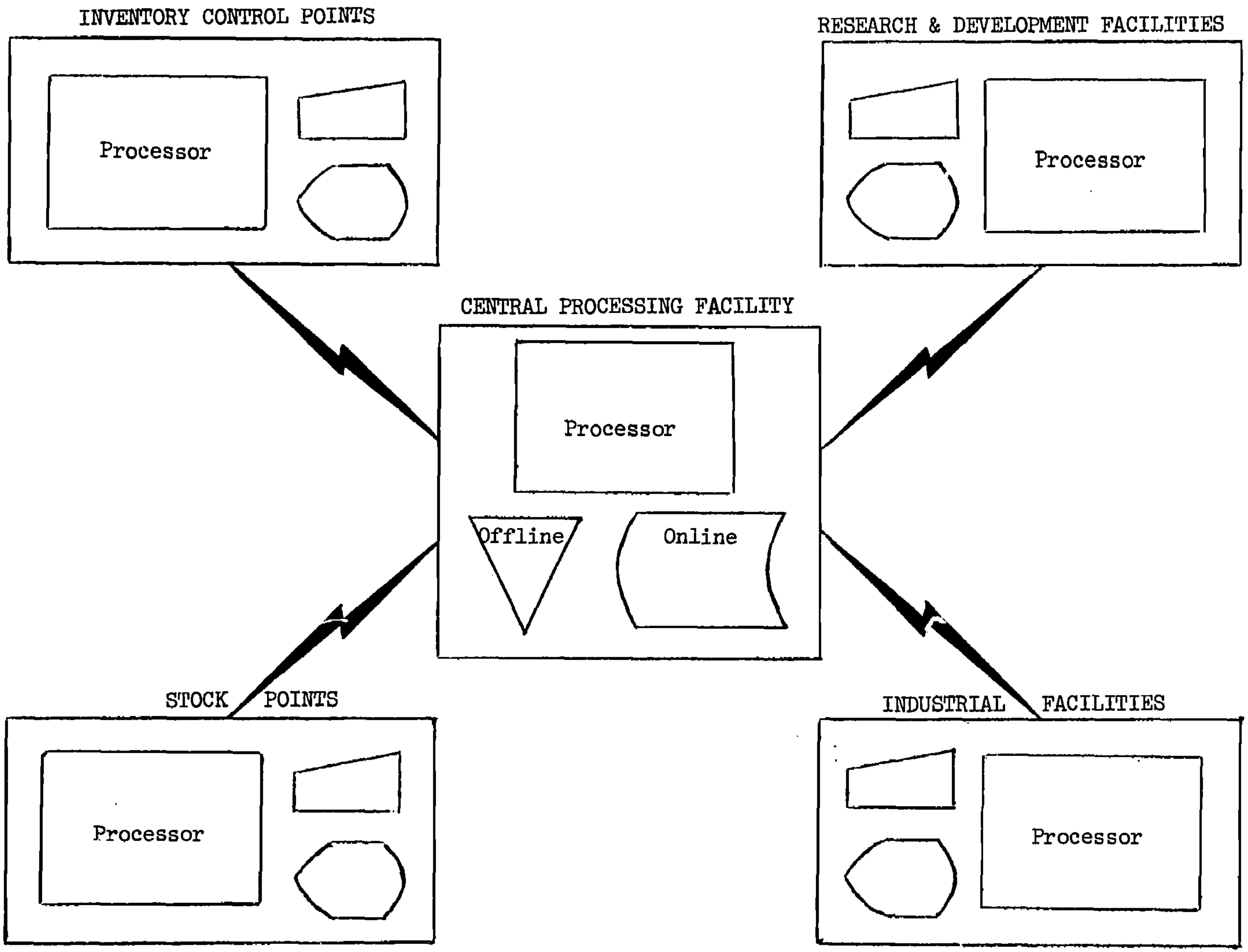


EXHIBIT 2 - SCHEMATIC OF A CENTRALIZED/DECENTRALIZED TECHNICAL DATA HANDLING SYSTEM

number of queries. This type of system would allow the computer at each of the individual facilities to communicate and/or receive processed information possibly on a time-shared basis from the centralized facility for reformating their presentation to the required users. In addition, each facility would then only require that size computer necessary to perform its own unique data processing functions. If the facility's own requirements do not necessitate the use of a large-scale computer, a small-scale, low-cost computer could be purchased to perform the required overhead functions involved in data communications as well as the facility's own unique processing.

CHAPTER III

FORECAST

A. Background

By the late 1950's, the technological revolution had taken on all the major aspects of the earlier industrial revolution - except for an appreciable shortening of response time. The extended periods of time previously available for muddling through are simply no longer available. While no single reason can be credited for the attention technology has received, two major factors can be identified: (1) A growing awareness that a nation's rate of economic growth depends heavily on changing technology, and (2) Continued international tensions have made it painfully obvious that national security depends on the output of military research and development effort.

This condition generated the urgent need for new planning tools. The military departments, a few aerospace firms, and some specialized consultants developed technological forecasting to help fill this need. The following is a brief summary of this development.

The U. S. Army, in 1957, initiated a "Long Range Technological Forecast" which describes knowledge, capabilities, and examples of materiel that science and technology can be expected to produce if supported by orderly programs of research and development. It is updated and published annually. This forecast is used by operational, organizational, and research and development long-range planners in the formulating of new concepts, requirements, and plans.

In 1945, the Army Air Corps conducted a study entitled "Toward New Horizons." The latest effort published in 1964 was a major technological

forecast in-depth known as "Project Forecast." In this forecast the Air Force related the predicted state-of-the-art to new system concept studies. The forecasting of technology, including analysis of threat, military capabilities, costs, etc., was done by technical panels (each unique to a technical area) and published in individual panel reports. Updating of "Project Forecast" is accomplished through periodic review by the technical panels. This forecast has impact upon numerous Air Force technical objectives and technical planning documents which are updated every 12 to 18 months.[1]

The Marine Corps presently considers the Navy Technological Forecast as well as the Army "Long Range Technological Forecast," interpreting it in terms of specific Corps applications.[2] In addition, under Marine Corps sponsorship, the Syracuse University Research Corp. performed a study during 1963-1964 entitled "The United States and the World in the 1985 Era."[3] This effort examined projected national objectives and policies, as well as the international and domestic military, economic, and technological factors affecting the United States into 1985.

1 Marvin J. Cetron, "Background and Utility of Technological Forecasting in the Military," Long-Range Forecasting and Planning, A Symposium held at the U. S. Air Force Academy, Colorado, 16-17 August 1966, p. 6.

2 Interservice Technological Forecasting Methodology Study Group, Report on Technological Forecasting, 30 June 1967.

3 This work is documented in a series of four technical reports:

Syracuse University Research Corp., The United States and the World in the 1985 Era, March 1964.

Syracuse University Research Corp., Appendixes One and Two to the United States and the World in the 1985 Era, May 1964.

Syracuse University Research Corp., Science and Technology in the 1985 Era, March 1964.

Syracuse University Research Corp., Appendix to Science and Technology in the 1985 Era, May 1964.

In 1965, the U. S. Navy appointed a study group to look into the needs for a formal technological forecast. A six-month study that included visits to both industrial and government research and development installations was performed. The study group recommendation stated that such a forecast would be very useful to the Navy in its long range planning effort and formulated a proposed method of conducting a technological forecast within the Navy, and a plan for its implementation.[4] The Chief of Naval Development initiated the NTF (Navy Technological Forecast) Program on 18 February 1968. This program presents scientific and technical extrapolation of technology, for a 20-year time-frame, using the present state-of-the-art as the base for projections. It will be updated and published annually in three sections:

Part I - Scientific Opportunities

Part II - Technological Capabilities

Part III - Probable Systems Concepts

The NTF, though born in a research and development laboratory environment, is not totally oriented toward the hard sciences - it also considers the non-physical; for example, concepts, attitudes and procedures. It is designed as a tool which facilitates both planning and decision-making.

[4] The Navy's Technological Forecasting Program is discussed in the following documents:

Marvin J. Cetron, et al., A Proposal for a Navy Technological Forecast, Part 1 - Summary Report (Washington, D.C.: Navy Technological Forecasting Study Group, 1 May 1966).

Marvin J. Cetron, et al., A Proposal for a Navy Technological Forecast, Part 2 - Backup Report (Washington, D.C.: Navy Technological Forecasting Study Group, 1 May 1966).

Interservice Technological Forecasting Methodology Study Group, op. cit., Management and Economics Research, Inc., draft, Impact of Future Technology on Navy Business Management: Vol. 2 - Technological Forecast, May 1967.

John P. Bartley, "Planning in NAVSUP," Navy Supply Corps Newsletter, November 1967, Vol. XXX, No. 11, pp. 14-19.

B. Deciding on a Technique

Preparations for the NAVSUP technological forecast in the field of information-processing led to a study of intuitive methods and resulted in the utilization of a variation on the DELPHI approach. This research and experience is described and evaluated here.

1. Intuitive Methods

One of the most direct and widely-used methods of generating a forecast is to sample the opinions of one or more persons who are knowledgeable in the specific technology or technological area under consideration. When more than one forecaster is involved, the forecast is built from a consensus or composite of estimates.[5]

There can be considerable merit in a forecast made by a single individual who is expert in his special area. Such a person must have both depth in the underlying scientific disciplines or technologies and also a concise view of the functional area to which his expertise has direct application. The literature abounds with the works of such authors as Anshen, Barach, Brown, Zahl, de Jouvenel, Gabor, Haydon, Kahn, and Ozbekhan.[6]

[5] James R. Bright (ed.), Technological Forecasting for Industry and Government: Methods and Applications (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1968), p. 56.

[6] Excellent examples of individual intuitive forecasts can be found in:

Melvin Anshen and George L. Bach, Management and Corporation 1985, (New York: McGraw-Hill, 1960).

Arnold B. Barach, 1975 and the Changes to Come, (New York: Harper & Brothers, 1962).

Harrison Brown, James Bonner, and John Weir, The Next Hundred Years, (New York: The Viking Press, 1957).

Dennis Gabor, Inventing the Future, (New York: Knopf, 1964).

Herman Kahn and Anthony J. Wiener, The Year 2000: A Framework for Speculation on the Next Thirty-Three Years, (New York: Macmillan, 1967).

Harold A. Zahl, Looking Ahead in Science and Technology, (Fort Monmouth, N.J.: Army Electronics Labs, November 1964).

Bownlee Haydon, The Year 2000, (Santa Monica, Cal.: Rand Corp., March 1967).

Hasan Ozbekhan, Technology and Man's Future, (Santa Monica, Cal.: System Development Corp., 27 May 1966).

To overcome the difficulty inherent in a single estimate, the judgments of a number of individuals who are active in a given field may be combined. This presumes that a realistic forecast can be obtained by cancelling out the errors of individual predictions. Extreme care must be exercised in drawing the sample of participants.

This panel brings individual experts together and provides for a desirable interaction of their diverse opinions. Navy's "Project Seabed," and Air Force's "Project Forecast," are two interesting examples of panel operations.

H. Wells and R. Lenz[7] initiated work on an interesting variation of the panel approach. The DELPHI technique is directed toward the systematic solicitation of expert opinion. Instead of using the traditional approach toward achieving consensus through open discussion, this technique eliminates committee activity completely,[8] This is done to reduce the influence of such psychological factors as fallacious persuasion, unwillingness to abandon publicly expressed opinions, and the bandwagon effect of majority opinion. It replaces direct debate by a careful program of sequential individual interrogations (usually in questionnaire form). These interrogations are interspersed with information and opinion feedback derived from results representing more than one consensus. These results are computed from earlier parts of the program. Both inquiries concerning their own reasons and subsequent feedback of the reasons presented by others may serve to stimulate the experts to consider points which they had inadvertently neglected, and give more weight to factors they had dismissed, on first

[7] Ralph C. Lenz, Jr., Forecasts of Exploding Technologies by Trend Extrapolation (Wright-Patterson AFB, Ohio: Aeronautical Systems Division).

[8] Erich Jantsch, Technological Forecasting in Perspective (Paris: Organization for Economic Co-Operation and Development, 1967), p. 137.

thought, as unimportant. The first full-scale application of this technique was called DELPHI. The DELPHI approach to technological forecasting has been researched and modified through work at RAND[9], primarily conducted by O. Helmer[10] with substantial support from Gordon[11], Brown[12], and Dalkey[13].

2. Preparative Investigation

The idea of tapping a wide spectrum of expert opinion is quite appealing on face value. This strategy appears even more attractive when the panel members are permitted [after doing their "home work," by producing the formal or informal technological forecast], as in DELPHI, to interact with each other's ideas in an anonymous atmosphere.

NAVSUP, Research and Development Division, is one participating activity in the NTF. This group was assigned the continuing responsibility for conducting forecasts in technologies related to Navy Logistics, with an initial effort in the area of information-processing technology.

NAVSUP became interested in the DELPHI approach to thoroughly investigate this technique's potential for producing user-oriented forecasts. After reviewing the previously cited DELPHI literature, meetings were

9 Olaf Helmer, Analysis of the Future: The DELPHI Method (Santa Monica, Cal.: Rand Corp., March 1967).

10 Olaf Helmer, Prospects of Technological Progress (Santa Monica, Cal.: Rand Corp., August 1967).

11 T. J. Gordon and Olaf Helmer, Report on a Long-Range Forecasting Study (Santa Monica, Cal.: Rand Corp., September 1964).

12 Bernice Brown and Olaf Helmer, Improving the Reliability of Estimates Obtained from a Consensus of Experts (Santa Monica, Cal.: Rand Corp., September 1967).

13 Norman C. Dalkey, DELPHI (Santa Monica, Cal.: Rand Corp., October 1967).

held with Dr. Helmer of Rand Corp. and with Dr. H. Q. North and Mr. D. L. Pyke of TRW, Inc., in order to discuss the problems and pitfalls of DELPHI. TRW was in the process of evaluating "Probe I,"[14] an attempt to employ the DELPHI method in an industrial environment. These conversations concerned the modification to DELPHI that TRW was contemplating in its effort to make "Probe II," a follow up study, more user-oriented. The essence of these modifications can be found in a presentation Dr. North recently made to the NATO Defense Research Group.[15]

As research progressed, questions raised concerning DELPHI were becoming more concrete. Prior to formalizing these questions and amorphous doubts, an effort was made to obtain a firmer basis in the conduct and employment of user-oriented forecasts. This research led to the study of articles, books, and technical papers listed in the Bibliography.

During this period much soul-searching transpired which resulted in a list of shortcomings in the current DELPHI methodology. This list was validated through conversations with experienced former panel members. The major drawbacks in this list include:

a. Panel members dislike beginning with a blank piece of paper. A set of sample projections would improve the panel members understanding of his task and stimulate patterns of thought.

b. The extensive number of interactions required by the DELPHI process results in a heavy investment of time. The panelist is prone to resent this imposition.

14 H. Q. North, A Probe of TRW's Future (Redondo Beach, Cal.: TRW Systems, 5 July 1966).

15 H. Q. North, "Technological Forecasting in Industry," A presentation during a Seminar to the NATO Defense Research Group, Teddington, Middlesex, England, 12 November 1968.

c. After the several rounds, the panelist may be faced with evaluating projections in areas totally outside his area of expertise. Several former panelists indicated much indignation over being asked to play the role of "expert" and being forced to give a layman's view under the guise of expert opinion.

d. A lack of goal orientation leaves the questions: When has the information been refined enough? When do we stop the iteration process?

e. Efforts to determine event feasibility and desirability are barely addressed.

f. Most importantly, no effort is made to (a) determine event interrelationships; (b) prepare "menus" of alternative short-, mid-, and long-range goals; or (c) identify the supporting events desirable and necessary to make these goals achievable.

g. The basic design of such a technique precludes the (hopefully empathetic) give-and-take potentially possible in face-to-face confrontation.

NAVSUP decided to develop a modified DELPHI technique (SEER) and test it in a project for the purpose of forecasting information-processing technology. This approach is designed to take advantage of DELPHI's strong points and avoid its weaknesses.

C. The SEER Technique

SEER is made up of two phases or rounds. In Round I of the forecast described, industry was asked to provide a data base. Approximately 85 innovative firms producing both hardware and software were contacted (see Appendix A). They were asked to select several top-level experts to participate in evaluation of a pre-prepared list of potential events.

This list was developed through a literature search[16] and a series of primary interviews of users and producers from government, industry, and academia. Several of these sample events appear in Exhibit 1. The influence of TRW, Inc.'s experience on "Probe I"[17] upon Round I approach and format is readily apparent.

The evaluators were usually product planners, research and development engineers, and/or operational engineers. Each of these participants was asked to add and evaluate additional events related to his area of expertise; he was also permitted to perform similarly in sub-categories of technology of tangential interest. These evaluations were made utilizing the following parameters:

- User Desirability - He was asked to consider the need to make the results of a given event available as a usable product.
- Producer Feasibility - He was asked to consider the technical, economic, and commercial feasibility of converting the event into a usable product.
- Probable Timing - He was asked to project a series of three dates for each event: a date of "reasonable chance" ($p = 0.2$), a "most likely" date ($p = 0.5$), and an "almost certain" date ($p = 0.9$).

Thus, Round I was basically an application of intuitive techniques; yet, is designed to permit the participant to base his comments upon more formal technological forecasts such as trend extrapolation, trend correlation analysis, etc.

Two approaches were used to view information-processing: (1) functionally (hardware and software) and (2) system-oriented.

16 See Bibliography for range of source documents.

17 North, op. cit., A Probe of TRW's Future.

POTPOURRI OF EVENTS FROM DATA BANK

EVENTS	USER DESIRABILITY: Needed Desparately	USER DESIRABILITY: Desirable	USER DESIRABILITY: Undesirable but Possible	PRODUCER FEASIBILITY: Highly Feasible	PRODUCER FEASIBILITY: Likely	PRODUCER FEASIBILITY: Unlikely but Possible	PROBABLE TIMING (Year by which the probability is x that the event will have occurred): x=.20	x=.50	x=.90
Breakthrough in long-range weather and sea state forecasting for Naval forces at sea.	X				X		72	76	85
LSI (Large-Scale Integrated) circuits may make small computers so inexpensive that each scientist would have one on his desk.		X			X		75	80	85
Large memories (perhaps hierarchies of memory) will be shared by many computers.		X			X		71	73	75
Low error rate-human operated, remote keyboards, used with self-checking numeric systems will be used in parts ordering, inventorying, etc. in conjunction with central computer systems and DDD communications (direct distance dial).	X			X			70	72	75
There will be greater standardization of data systems and procedures in order to use standard software and programs in conventional type business operations.		X		X			72	75	80
Digitized voice/analog transmission between central offices and switching centers to facilitate time-division multiplexing, encryption and switching.	X				X		71	74	78

The functional approach is divided into 11 categories:

1. Pattern Recognition Equipment
2. Circuits and Modules
3. Computers and Calculators
4. Data Communications Equipment
5. Graphic Data Systems and Devices
6. Memory Systems and Magnetic Recorders
7. Peripherals
8. Microforms and Related Equipments
9. Facsimile and Reproduction Equipment
10. Long Distance Communications
11. Software

The systems-oriented approach is divided into three categories:

12. Computer Organization
13. Systems and Applications
14. Standards

Inputs from Round I participants were gathered during the early summer months of 1968 and converted into the Round I Data Bank. Round II attempted to refine and extend the Round I results. It involved an attempt to interpret event significance in relation to the total information-processing environment in which the Navy will have to operate in the future. Round II serves three functions: (1) a reevaluation and expansion of the data base; (2) a delineation of the interactions among the events forecasted; and (3) an extension of the state-of-the-art in technological forecasting. During this round, a group of outstanding individuals in the field of information-processing was asked to evaluate the Round I data base to refine and augment

the data base, to identify events of importance, and to determine possible interrelationships between events.

This group was made up of over 45 representatives of government, industry, and the academic world (see Appendix A). Each of these experts was assigned one or more categories for consideration. Assignments were made to consider each expert's area(s) of expertise; representation was assured from government, industry, and academia in each specialty. A careful attempt was made to balance the attitudes of participants to molify "ax grinding" tendencies.

Round II was a direct application of the normative approach. It should be stressed that Round I was an attempt to provide a data base; whereas, Round II was an attempt to refine, extend, and structure the data base to enhance the value of this forecast for planning and system design personnel.

After receiving the inputs from the panel of Round II experts, a refined list of potential events was produced (see Section D - Data Bank of Events). This list was used to develop a "menu" of alternative potential short-, mid-, and long-range goals and to identify supporting events which may be desirable or even necessary to make these goals achievable. An Event Interrelationship technique was used to document alternative pathways from the current state-of-the-art to where it <u>will</u> be in the future (see Chapter IV - Operational Implications).

D. <u>Data Bank of Events</u>

This Section summarizes the results of Round II of this study. Each of the 14 categories of information-processing technology cited in Section C is discussed in terms of a list of potential events. Each event is evaluated in four ways:

1. Goal - The experts were asked to designate major events. Those events designated by the category panel as major were treated as potential goals. Those goals considered to have a better than 50% probability of being achieved by 1975 were designated as short-term, signified by S. Those goals not meeting the short-range requirement yet having a better than 50% probability of being achieved by 1983 were designated as mid-range, signified by M. Those goals considered by the experts to meet the probability of success requirement only after 1983 were considered long-range, signified by L. To prevent errors of omission, those events not qualifying as goals were designated not applicable, signified by N/A.

2. Desirability - The experts were asked to consider, from the user's point of view, the need to make the results of each event available as a usable product. The evaluation is expressed as an index from 1 to 9: 1 signifies undesirable but possible; 5 signifies desirable; and 9 signifies highly desirable. The value assigned to each event was calculated as an average rounded to the nearest whole number. The intermediate desirability index values then indicate moderating degrees of intensity.

3. Feasibility - The experts were asked to evaluate, from the producer's point of view, the technical, economic, and commercial feasibility of converting the event into a usable product The evaluation is expressed as an index from 1 to 9: 1 signifies unlikely but possible; 5 signifies feasible; and 9 signifies highly feasible. The value assigned to each event was calculated as an average rounded to the nearest whole number. The intermediate feasibility index values then indicate moderating degrees of intensity.

4. Timing - The expected time of event occurrence is depicted by a triangel: the year by which there is a "reasonable chance" that the event will have occurred (probability of 20%) is indicated by the left tip; the year by which the event is "almost certain" to have occurred (probability of 90%) is indicated by the right tip; and the "expected" year of occurrence (probability of 50%) is indicated by the vertex.

CATEGORY - 1. PATTERN RECOGNITION EQUIPMENT

	EVENT	Goal	Desirability	Feasibility	Timing
a.	Optical character reading (OCR) will accelerate the phasing out of key-punched data inputs.	S	7	7	72 74 77
b.	Page readers will replace key-punching for data input in conjunction with magnetic tape recorders.	N/A	5	7	72 74 77
c.	Faster and more reliable document readers will be available at 10,000 characters per second.	N/A	5	5	72 77 81
d.	Techniques for computer reading of print and handwritten print will have been developed. No current or envisaged system is adequate.	N/A	5	3	72 75 85
e.	Computer recognition of 3-D objects will permit automatic processing and understanding of photos, TV and motion picture film.	N/A	5	5	74 80 90
f.	Optical character readers capable of automatically reading multifont characters (i.e., greater than 20 fonts) will be available.	N/A	5	9	72 74 77
g.	Commercially available pattern recognition equipment for input of graphic data (bar charts, diagrams, etc.).	M	5	5	75 80 85
h.	Low cost OCR reader (less than $20,000).	S	8	8	70 72 74
i.	Pattern reader used commercially in medical field analysis (hospitals).	N/A	9	9	71 73 75
j.	Pattern reader for recognition of spoken words with limited vocabulary.	N/A	5	5	74 80 90
k.	Pattern reader for recognition of spoken words with little vocabulary limitations.	N/A	5	2	80 85 95
l.	Remote scanning will be commercially available.	S	8	8	70 71 72
m.	OCR will be a major technique for the transmission of digital data.	N/A	5	8	72 74 76
n.	Adaptive recognition techniques will be implemented into the pattern recognition equipment.	N/A	5	5	74 78 81

CATEGORY - 1. PATTERN RECOGNITION EQUIPMENT (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
o.	Some form of computer voice input will be available.	M	5	5	74, 80, 85
p.	OCR will play an active role in the computer storage of present documentation files for library, books, journals, abstracts, files, indices, etc.	S	8	8	72, 74, 78
q.	Reading of U. S. mail will be basically by OCR (Zip code and address).	L	8	8	80, 85, 90
r.	On-line interpretation of reconnaissance photographic data.	M	8	8	75, 80, 85
s.	Techniques for reading of script will have been developed.	N/A	5	5	77, 79, 84
t.	Techniques for reliable reading of printed alphanumeric characters will have been developed.	N/A	8	8	70, 72, 75
u.	Very reliable OCR equipment capable of reading hand printed numerics will be developed.	N/A	8	8	72, 76, 74
v.	Moderately slow low-cost OCR transmittal equipment will be developed.	N/A	8	8	69, 71, 73
w.	A larger selection of reliable multifont OCR equipment will become available.	N/A	5	8	73, 76, 79
x.	Faster (2,000 documents/min.) small document readers with sorting capabilities will be developed.	N/A	5	5	70, 73, 75
y.	Techniques for machine reading of general print will have been developed (for books, newspapers, etc.)	M	7	8	72, 75, 85
z.	Techniques for machine reading of script will have been developed. (Requires memories of very large capacity for storing of context.)	L	7	5	75, 80, 2000
aa.	Optical page readers will use spelling, grammar, and context to check individual characters.	N/A	8	8	71, 75, 80

CATEGORY - PATTERN RECOGNITION EQUIPMENT (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
bb.	Recognition of line drawings and perhaps more sophisticated input material will be possible.	N/A	5	5	80 85 90
cc.	Personal characteristics such as fingerprints, facial features, etc. will be useful for identification.	N/A	5	5	85 90 2000
dd.	Techniques for on-line handprint and script entry using graphic input devices and small (less than $10 K) computers with simple programs will be available.	S	5	5	69 70 75
ee.	Speech recognition devices capable of recognizing dozens of speakers using the systems.	N/A	6	5	73 77 83
ff.	Reception and encoding of spoken data limited to data identifiers and numerical data will be possible.	N/A	6	5	70 75 80
gg.	For spoken input, computers will identify a few tens of words.	N/A	5	6	70 75 80
hh.	For spoken input, computer vocabulary will be many hundreds of words, and computer will interpret simple sentences.	S	9	5	70 72 75
ii.	Computer will use for both spoken input and audio output the extent of vocabulary and the idiomatic usage as does an educated person.	L	7	3	75 80 2000
jj.	Spoken reply to digital input.	N/A	5	7	68 70 72
kk.	Spoken input will be recoded and reconstituted for verification.	N/A	5	5	70 74 78
ll.	Natural syntax and symbols including motion pictures will be accepted, but not recognized, by computers.	L	5	3	76 82 90
mm.	Some form of voice input and output will be in common use.	S	9	4	71 74 78
nn.	Need for facsimile and OCR (Optical Character Readers) may be eliminated by use of dual-mode documents containing both digital, machine-readable, high density codes and conventional man-readable printing.	N/A	2	6	71 73 77

CATEGORY - 2. CIRCUITS AND MODULES

EVENT	Goal	Desirability	Feasibility	Timing
a. Speed of computing circuits is likely to increase significantly, because of increased use of miniaturized components, high speed computing elements, and automated design procedures.	N/A	6	7	72 75 77
b. Faster clocks will be used to produce more rapid internal processing. A greater use of integrated circuits will allow more pulses to be used to initiate functions.	M	6	7	72 75 77
c. More logical functions will be incorporated into the hardware, thereby increasing hardware complexity, but reducing that of software.	S	6	6	71 74 76
d. There will be little reason to place any limitation on the number of registers available to a machine because each register will essentially be a simple monolithic chip. The removal of this restriction makes the use of multiprocessing more economically feasible. Similar effects can be expected for scratch pad memories.	M	6	6	72 75 77
e. Cheaper, smaller, and faster circuitry in CPU will permit greater parallelism (circuit redundancy), too expensive to contemplate today.	M	6	6	72 75 79
f. Low cost computer hardware will justify inefficient (by today's standards) but vast numbers of computations and handling processes.	N/A	4	6	72 76 79
g. The transition from discrete transistors to integrated circuits is in process. Further improvement (speed, reliability, cost, etc.) in circuits may be expected through "molecular electronics" employing distributed elements. Such circuits will be:				
(1) introduced.	N/A	5	5	70 73 80
(2) Used in complex high volume industrial applications (i.e., computers, telephone circuits).	N/A	5	5	72 75 81
h. Development of redundant logic switching theory permitting uninterrupted performance of systems during small-scale failure.	M	5	5	71 76 81

CATEGORY - 2. CIRCUITS AND MODULES (Cont'd.)

EVENT	Goal	Desirability	Feasibility	Timing
i. Widespread use of LSI in processor circuitry. The cost of peripherals will become the major system cost.	S	7	5	70 71 73
j. Packaging, manufacturing, and circuit technology will develop low cost methods which will make it possible to produce a line of digital "Erector Set" modules at costs lower than specially wired functional circuits for device control applications. This concept is particularly applicable to small-scale, inexpensive computers.	N/A	7	7	71 72 75
k. Laser devices can be used as active elements, i.e., gates, flip-flops, and amplifiers, in most computers.	N/A	2	2	90 2000 2050
l. The use of large scale integrated circuit technology on a truly integrated basis.				
(1) ten-fold.	S	5	6	70 72 73
(2) hundred-fold.	M	6	5	72 75 80
m. Use of light emitting diodes and similar electronics for data processing reading, and display.				
(1) ten-fold.	N/A	5	5	70 72 75
(2) hundred-fold.	N/A	6	5	75 80 85
n. Sophisticated micro-electronics will permit design of very compact self-contained modular input terminals.	S	7	7	69 72 74
o. Increase in use of fluidic devices for certain control and logic functions, automation, etc., will result in increased reliability, but will only have a negligible effect on speed.				
(1) ten-fold increase in use.	N/A	5	5	70 72 75
(2) hundred-fold increase in use.	N/A	3	5	75 80 85

CATEGORY - 2. CIRCUITS AND MODULES (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
p.	Dependence on human observation and judgment in testing modules at the point of manufacture will be eliminated.	N/A	8	5	70 73 80
q.	Cheaper, smaller, and faster circuitry will permit more power at remote terminals tied to central systems.	N/A	8	8	73 75 78
r.	LSI may make small computers so inexpensive that each scientist would have one on his desk.	N/A	5	5	75 80 85
s.	Logical functions of a special nature will be simple to add to one's system (cheap, modular, made to order).	N/A	5	5	73 75 77
t.	Modules may be purchased to construct one's own special purpose computer.	N/A	5	5	72 75 80
u.	Packing densities will increase by an order of magnitude on IC modules.	N/A	5	5	70 73 76
v.	Newly developed, hot-pressed ferroelectric ceramics will be used for at least the following:				
	(1) High-density (5-20 k bits/in^2) electro-optic storage devices.	N/A	5	4	70 73 76
	(2) Controlled persistence displays.	N/A	5	5	70 73 76
	(3) Electro-optic and acousto-optic deflection and <u>modulation</u> devices.	N/A	5	5	69 71 76
w.	The development of high-level monolithic drive circuitry including integrated sense amplifiers with decreased recovery time.	N/A	5	6	69 70 71
x.	Built-in hardware to ease programming problem; to ease executive control overhead; to facilitate debugging.	S	8	6	70 72 75
y.	Primitives, complex subroutines in hardware, used like instructions.	N/A	7	8	71 73 75

CATEGORY - 3. COMPUTERS AND CALCULATORS

	EVENT	Goal	Desirability	Feasibility	Timing
a.	Computer interpretation of voice will be feasible.	M	9	4	74 80 87
b.	Computers specifically designed to efficiently handle sorting applications will be available.	N/A	4	6	71 73 77
c.	Distinction between military and commercial computers will largely disappear.	M	5	8	73 75 80
d.	A new class of machines available will be the information retrieval system. They will be characterized by very large memory requirements, and the ability to handle large memories including multiple peripheral systems.	M	9	5	72 75 79
e.	Cost/operation will drop by a factor of 200 from current levels, and will be available in fifth generation computers.	M	9	5	74 78 85
f.	Very cheap special purpose computers to solve specific data processing problems in standardized ways may be available.	N/A	8	5	71 73 75
g.	Computers able to "understand" and communicate in limited English may be available.				
	(1) limited vocabulary of a few dozen words.	N/A	5	5	72 75 80
	(2) a significantly enlarged vocabulary.	M	8	5	75 80 85
h.	Personal computers - worn like a watch coupled with communications network.	N/A	5	5	75 80 85
i.	Analog computers with stored program capability.	N/A	6	6	71 75 80
j.	A new form of computer using hybrid components.	N/A	3	3	71 74 79
k.	Development of parallel processing equipment (Orthogonal Computer) will continue to evolve.	N/A	9	6	72 75 80

CATEGORY - 3. COMPUTERS AND CALCULATORS (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
l.	Development of Communications-type Processors.	S	9	8	69 70 71
m.	Low cost computers less than $3,000/unit will be available using software to replace high cost arithmetic units in the CPU - eventually leading to portable - rugged units.	N/A	6	6	73 74 75
n.	Special purpose official computer - filtering, data reduction, etc.	N/A	3	3	71 72 74
o.	Computers will be designed to be taught sequentially by their users, just as a child can be, and that will grow with their environment.	N/A	2	1	78 83 88
p.	The use and acceptability of small (under $10,000) general purpose digital computers will continue to increase.	S	8	9	70 74 78
q.	The number of small computers put on-line in scientific experiments will increase at a greater rate than the rest of the market.	N/A	5	8	70 72 75

CATEGORY - 4: DATA COMMUNICATIONS EQUIPMENT

EVENT	Goal	Desirability	Feasibility	Timing
a. "Smart" terminals will be developed to permit most of the computing and processing to be done in the terminal (going over a communications line to a larger computer only when necessary) to minimize communications costs.	N/A	8	8	68 69 70
b. Teleprinters will substantially replace line printers.	N/A	6	7	73 75 80
c. Teleprinters will commonly be supplanted by CRT's (cathode ray tubes).	N/A	2	7	72 75 80
d. Practical application of optical electronic communication and computer equipment will be feasible.	N/A	5	5	73 78 85
e. I/O data communication terminals will become more versatile at higher speeds and lower costs by sharing common control electronics within geographical clusters.	S	6	6	71 73 76
f. Automated circuit switch control of private data networks.	N/A	8	8	68 70 72
g. Interconnection of private and public switched voiceband networks.	S	5	6	70 71 73
h. Small scale computer time-sharing systems operating within each major local dial area will become common to avoid toll charges for transmission between terminals and computer.	N/A	8	8	69 71 73
i. Increased multiple processing capabilities of computers will permit general purpose computers to perform message collection, editing and forwarding on a part-time basis.	N/A	5	8	70 73 75
j. Modem speeds of:				
(1) 7200 bps data transmission reliably performed on voice grade (nominal 3kHz) lines.	S	7	8	69 70 72
(2) 9600 bps data transmission reliably performed on voice grade lines.	S	6	5	69 71 73
(3) 12,000 bps data transmission reliably performed on voice grade lines.	S	6	5	71 72 75

CATEGORY - 4. DATA COMMUNICATIONS EQUIPMENT (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
k.	Plug-in jacks on some telephones will allow convenient portable use of digital communication devices at moderate speeds.	S	7	8	70 72 75
l.	Lifting of restrictions on attachments to the AT&T Co. DDD (Direct Distance Dial) network with suitable interface.	N/A	6	8	68 69 70
m.	Computer terminals will provide efficient transmission on primary communication system lines to switching centers and other computer terminals	N/A	5	8	70 72 74
n.	Pulse-code modulation communication capability will be available for information center network communications.	N/A	6	8	68 73 75
o.	Cryptographic devices will be commonly used for voice communications for business and private data.	N/A	5	6	72 76 81
p.	Voice answer-back from computer data base will find widespread use for simple inquiry-response systems using the touch-tone phone as a remote terminal.	N/A	6	8	70 75 80
q.	Touch-tone dial as input to computers and graphic print out remote.	S	6	8	69 70 71
r.	Desk top, low-cost, manually operated data communication terminals using DDD network will be commonplace.	S	8	8	70 71 72
s.	Small message composition devices will be used for on-line programming and file query from remote locations so that the fixed portion of high level programming or query language statements can be entered error free.	N/A	4	8	69 71 73

CATEGORY - 5. GRAPHIC DATA SYSTEMS AND DEVICES

EVENT	Goal	Desirability	Feasibility	Timing
a. Automatic drafting techniques (digigraphics), permitting the updating of old drawings, preparation of new design drawings, manipulation of elements of drawings that permit changes in scale and viewing angle.	S	6	8	67 72 75
b. Large screen color television with laser beams and mechanical mirror scanning will be available.	N/A	4	5	75 77 79
c. A flat TV tube providing reduced glare, will be available on the market at reduced cost.	N/A	5	4	71 74 78
d. Solid state direct view display devices with selective erasure characteristics will be available.	S	5	5	71 73 76
e. 3-D replication of moving objects will be technically feasible.	N/A	5	6	73 77 81
f. The capabilities of the output display system will increase as it becomes more economical to incorporate greater amounts of storage and data handling facilities within the peripheral equipment rather than the CPU.	S	5	7	69 72 75
g. Soft-copy, e.g., cathode ray tube (CRT) displays, known as second-generation equipment, will increase in use rapidly as they operate at electronic speeds.	S	7	8	67 69 72
h. The use of plotters, including desk size plotters, will increase as management turns more and more to the everyday working use of computers for information. However, soft-copy should be good enough at a remote terminal.	N/A	4	7	69 71 74
i. Low-cost, fast selective erase variable storage time CRT capable of data readout to significantly reduce cost of graphic man-machine CRT terminals	N/A	8	6	72 74 76
j. Low-cost fast mass memory (10^7 bits, 300 μHz bit rate) provides basis for low-cost TV CRT graphic terminal.	N/A	6	4	72 75 80
k. Man-oriented computer input device, refinement, or replacement of light pen, graphic tablet, etc.	N/A	5	5	72 74 76

CATEGORY - 5. GRAPHIC DATA SYSTEMS AND DEVICES (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
l.	An inespensive alphanumeric terminal (with limited graphic capability) will revolutionize this field at about $1K per terminal.	M	8	6	72 75 78
m.	Standard television sets will come into substantial use as I/O terminals.	S	8	8	70 72 75
n.	Development of low-cost, high-resolution, direct view storage CRT.	N/A	8	7	70 72 74
o.	Development of low-cost scan converters.	N/A	7	6	70 73 75
p.	Development of solid-state X-Y-Z displays of integral memory.	N/A	5	6	72 74 76
q.	A solid state, thin, large screen display device will be in general use as a TV display.	L	5	4	75 83 90
r.	A solid state vidicon will be available.	N/A	8	6	69 70 71
s.	A 3-color vidicon will be available, leading to relatively inexpensive color cameras.	N/A	8	7	71 72 75
t.	Inexpensive, high sensitivity vidicons for low light level applications will be available.	N/A	5	8	70 72 75
u.	Electron beam recording devices will be available.	N/A	7	7	69 72 75
v.	Page-size, dry-process hard copy CRT output device will be available.	S	9	8	69 71 73
w.	TV-raster I/O devices will be a replacement for many direct CRT displays because of capability for accepting both digital and video (background data from optical storage) inputs.	S	6	7	70 72 73
x.	Non-electromechanical, hard copy X-Y recording equipment for use as an analog or digital computer peripheral equipment with the following general characteristics: Large screen (plotting areas of up to 6' x 10') High speed (writing speeds of 100 inches/sec or greater) High accuracy (0.05% to 0.005% of full scale)	M	5	5	74 76 80

CATEGORY - 5. GRAPHIC DATA SYSTEMS AND DEVICES (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
y.	Graphic input to computers will mature beyond its current poorly engineered status.	S	8	8	69 72 74
z.	Mechanical laser scanners will be used to scan aperture cards for input to a computer.	N/A	6	7	69 71 73
aa.	All TV circuitry will be microelectronic.	N/A	5	5	73 75 78
bb.	Plotters will become computer peripheral devices with I/O speeds of 200K words/sec. These plotters will use direct electron beam recording onto film. Plotting speeds of 10^6 points/sec. and 120'p/mm resolution will be typical.	S	5	7	71 73 76
cc.	Film plotters will produce a finished aperture card in approximately 30 sec.	N/A	5	5	70 72 76
dd.	Digigraphic systems will use as a data base both graphical and digital information. Output will be in the form of film chips.	S	7	5	71 73 75
ee.	Development of effective solid-state laser deflection techniques.	N/A	5	5	73 77 81
ff.	Development of low-cost hard-copy adapters to be used in conjunction with electronic display devices (CRT's) with resolution equal to that of display devices and with printout time being less than 5 seconds (external) for displayed screen.	N/A	8	5	70 73 75
gg.	Improvements in Machine-Aided-Design systems can be expected with an output to accommodate machine made functional systems, including active and passive devices and machine made documentation including fabrication masks of necessary, logic diagrams, schematics, interconnecting diagrams, test parameters and testing diagrams. Inputs to these systems will be:				
	(1) Functional relation expressions.	N/A	8	8	70 72 75
	(2) Manual input of data (i.e., schematics).	N/A	8	8	68 70 72
	(3) Optical scanning of rough circuit sketches.	S	7	6	70 73 76

CATEGORY - 5. GRAPHIC DATA SYSTEMS AND DEVICES (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
hh.	A color display, 1024 x 1024 resolution, low cost-$1-10K including storage, will be available.	S	9	5	70 71 73
ii.	A hardware display generator which can draw curves, lines, points, and characters with edge clipping, fast and accurately will be available at a low cost ($1-5K).	N/A	8	5	69 70 73
jj.	A hardware picture generator which can generate a raster scan in color given the specifications of all the homogeneous areas will be available.	N/A	8	5	70 72 74
kk.	LSI technology will permit the inclusion of many special purpose processing functions in display generators thus saving central machine time (e.g., 3-D transformations).	N/A	5	8	70 72 74
ll.	The plasma panel will be perfected to provide a low cost, flat, easily driven, high resolution color display with selective write, intensity storage and read-out capacity.	N/A	5	8	69 70 72
mm.	High resolution (750-1000 line) TV refreshed from an analog or digital mass storage device (e.g., disc) either in clusters or individually will provide low cost, high performance graphics consoles.	N/A	5	8	69 70 72
nn.	Wall displays 4' to 12' square with resolution of at least 40 lines/inch and color will be feasible.	N/A	8	5	71 73 75
oo.	Development of flat panel, digitally addressed displays with inherent storage and selective erasure.	N/A	8	7	69 70 72
pp.	Development of dynamic real-time large screen displays.	S	8	5	70 72 74
qq.	Development of low cost remote graphic terminals.	S	7	7	71 74 76
rr.	Development of sophisticated man-machine interface consoles with high speed and high resolution graphic input and graphic output at reasonable cost for applications such as design automation.	N/A	9	9	69 70 72

CATEGORY - 5. GRAPHIC DATA SYSTEMS AND DEVICES (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
ss.	Reliable high resolution opaque scanner with 4-times the resolution presently available.	N/A	5	5	70 72 75
tt.	Holographic techniques may compete with and/or supersede the use of TV consoles for man/machine interface.	N/A	3	3	77 80 84
uu.	Telephone couples soft copy capability can be commonly used for information retrieval and presented to the individual viewer.	N/A	5	6	73 75 75
vv.	Personal terminals which "simulate" routine activities of employees in functional departments (e.g., personnel, contract administration, pricing, etc.) so as to increase productivity of administrative work.	N/A	8	8	70 72 75
ww.	Graphics capabilities will assume tremendous importance.	S	5	8	69 72 75

CATEGORY - 6. MEMORY SYSTEMS AND MAGNETIC RECORDERS

EVENT	Goal	Desirability	Feasibility	Timing
a. Expect capability to read (or write) more than one disk simultaneously for the same reason that we will be able to handle more than one block of data by duplication and redundancy of electronic units.	N/A	7	8	68 68 69
b. Disc packing density will show a 50% improvement over those currently available. Total disc capacity will increase as it becomes feasible to use larger or more discs per unit.	N/A	8	8	68 69 70
c. Memories will cycle at 0.5 microseconds.	N/A	9	8	68 68 69
d. Cost of high-speed operating storage will be 100 times less than in 1965.	N/A	8	5	71 74 78
(1) 40 to 50 percent improvement in cost/operation of central processor.	N/A	8	4	70 72 76
(2) 15 to 25 percent improvement in the cost/operation of an advanced hardware system.	N/A	5	5	70 71 72
(3) Six- to ten-fold improvement in throughput cost-effectiveness of overall EDP system (also contributed to by advances in circuit speeds).	M	5	5	75 80 85
e. Where average random access of less than one second is required:	N/A	5	5	68 69 70
(1) Card-strip-chip approach for digital or image data (0.001 mill/bit).	N/A	6	5	70 72 74
(2) Read-only photodisc for large, semipermanent digital files (10^{10} to 10^{12} bit capacities).	N/A	6	5	71 74 77
(3) Disc systems for 10^8 to 10^9 bit capacities (.1 to 1 mills per bit).	S	7	6	68 69 70
f. Magnetic tape storage will decline in cost from mill cent per bit to less than .1 millicent per bit.	N/A	5	5	71 74 77
g. Magnetic tapes and discs will have higher packing densities.	N/A	7	8	69 70 71

CATEGORY - 6. MEMORY SYSTEMS AND MAGNETIC RECORDERS (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
h.	Tape units may some day be replaced by monolithic ferrite memory. First applications will probably be internal to the central processing units for small scratch pad memories. Eventually it gives promise of rapid access to memory of billions of bits of data on an almost random basis.	N/A	6	4	72 75 80
i.	Nondestruct memories will be substantially reduced in both write time and cost.	N/A	5	7	69 71 73
j.	Electron beam recording devices will be available.	N/A	6	8	69 71 73
k.	A more brute force approach to a content addressing scheme may become economical as a result of larger core or film memories, much larger associative memories, and higher operating speeds.	N/A	4	4	71 73 75
l.	The use of very large but inexpensive memory units, together with repetitive circuitry, will permit the direct design of associative or content-addressed memory.	N/A	4	4	72 74 77
m.	Mass storage capacities:				
	(1) 10^{11} to 10^{12} bit capacity--average random access of a second or less (costs of much less than a millicent per bit).	M	8	8	72 75 78
	(2) 10^{7} to 10^{8} bit capacity--average speed of one micro-second (about 1 mill cent per bit).	S	8	8	70 72 74
	(3) Up to 10^{5} bit capacity--average speed 100 nano-seconds (4-20 cents per bit).	S	6	8	69 71 73
n.	Simultaneity will be achieved both by redundancy of data handling facilities within the disc unit and by duplication of head control mechanism.	N/A	5	7	68 68 69
o.	Laser-oriented memory and file storage. This type of memory opens new possibilities. Using the laser beam to interrogate mass random access memories, implemented as fixed arrays, would result in capacities of 10^{9} to 10^{10} bits at a cost of a few mils per bit. This opens up the possibility of combining file storage with operating memory for file-oriented logistics information systems.	N/A	6	5	73 76 79

CATEGORY - 6. MEMORY SYSTEMS AND MAGNETIC RECORDERS (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
p.	Use of LSI for small CAM memories in computers.	S	5	7	69 70 72
q.	Majority or at least equal use of anisotropic permalloy memories (films, plated wire) for computer main frame memory.	N/A	5	6	73 75 80
r.	Widespread use of LSI for computer memories.	M	6	5	72 76 79
s.	Erasable mass storage units of 10^{10} bit capacity will have access times less than 10 milli-seconds and cost .1 millicent per bit.	M	9	5	73 76 79
t.	Erasable mass storage units of 10^{13} bits capacity will have access times of less than 1 sec. and cost less than .1 mill/bit.	N/A	6	5	74 77 80
u.	Methods for utilizing close to the theoretically maximum density of magnetic material will be found, in an economical, realiable system.	N/A	5	3	80 85 87
v.	Radical new memory structures which grow new paths when stimulated electrically will be in use.	N/A	5	5	78 83 90
w.	Main memory storage will average 100-300 NS for 4th generation computers.	N/A	7	7	71 74 76
x.	Scratch pad memories will average 100 NS for 4th generation computers.	N/A	7	7	71 73 75
y.	Submicrosecond core memories will be available of 10 million (10^7 bits), costing 2.5 to 3 cents/bit.	N/A	5	5	70 73 75
z.	Both planar thin film and plated wires will gain industry acceptance, but ferrite cores will continue as the primary main memory storage element for 5-6 years.	N/A	5	4	72 74 76
aa.	Holographic techniques will be utilized to store digital, or possibly even alpha-numeric information, as a main storage element in a computer.	N/A	8	5	70 73 75
bb.	Cost reductions on cores, plate and wire or thin film for main storage will make it possible to provide lots of fast storage capacity. This will simplify the software convolutions of "virtual memory" and "paging" and make time sharing more economic than now.	S	6	4	71 73 75

CATEGORY - 6. MEMORY SYSTEMS AND MAGNETIC RECORDERS (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
cc.	High-speed ROM (Read Only Memory) Systems less than 100 ηsec. cycle times	N/A	7	7	69 70 72
dd.	Combined ROM and erasable memory systems in one physical unit sharing electronics.	N/A	5	5	68 68 69
ee.	Large scale associative content addressable memory systems.	S	6	4	70 72 74
ff.	Use of laser beam recording on magnetic media for wide band analogue and higher speed digital recording (50 megabit/sec.); increasing packing density by 10; reducing cost by a factor of 10; improving access time by a factor of 10.	N/A	7	4	71 73 75
gg.	Use of magnetic film memory coupled to IC to produce high-speed, low power, low cost RAM.	N/A	5	5	71 73 78
hh.	Use of optical techniques for CAM.	N/A	4	4	72 76 79
ii.	On-line memories with very high data reliability, access time of 5 seconds, capacities in excess of 10^{12} bits and cost of less than 10^{-3} cents/bit.	N/A	9	8	69 70 72
jj.	Semiconductor "cache" memories will extend the lifetime of ferrite core memories.	N/A	8	8	69 71 73
kk.	Disc paks will take over a major portion of the magnetic tape market due to increased reliability and performance.	N/A	8	5	70 73 76
ll.	Thin-film memories with cycle times of 250-400 NS will be available in stores of 10^5-10^6 bits.	N/A	6	4	69 70 71
mm.	Major semiconductor suppliers will not enter the computer business with LSI CPU's and memories. They will recognize that main memory and control processor has tended to be a smaller and smaller portion of the total computer system as the history of the art develops. The software requirements will be considered too monumental.	N/A	5	5	70 72 75

CATEGORY - 6. MEMORY SYSTEMS AND MAGNETIC RECORDERS (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
nn.	Monolithic LSI memories with access times of 50-100 NS (NDRO) will be available in stores of 10^4-10^5 bits for 10¢/bit.	N/A	6	6	70 71 73
oo.	MOS memories with access times of 1-2 microseconds (NDRO) will be available in stores of 10^5-10^6 bits for 2¢/bit.	N/A	6	5	71 73 75
pp.	A reduction in the cost of the magnetics array to further reduce costs of larger and faster systems will evolve.				
	(1) An improved ferrite material will be developed which enhances the operation of memory systems over wider environments and of faster speeds.	N/A	5	5	69 71 73
	(2) Automatic stringing of X, Y, sense and digit wires through the cores will be developed to reduce the cost of stacks and thus memory systems.	N/A	7	5	70 70 73
	(3) Improved ferrite material will be developed along with better testing procedures which result in 100% yield at stack level.	N/A	5	3	70 71 73
qq.	Larger, sub-microsecond cycle time memories will become more in demand as computer capabilities are extended to meet the requirements of the future.	N/A	8	8	69 69 70
rr.	Bulk core memories with a cycle time of 1-4 μsec. and a module capacity of 10^7 to 5×10^7 bits will be available at a customer cost of 1.0 cents per bit.	N/A	8	5	69 71 73
ss.	Three-dimensional photomemories will be working and inexpensive.	N/A	5	4	75 85 95
tt.	Commercially available superconductive mass memory (or equivalent).	N/A	5	5	72 75 80
uu.	Off-line analog storage.	N/A	6	7	68 71 75
vv.	Additional memory hierarchies will be introduced.	N/A	5	6	68 70 72

CATEGORY - 6. MEMORY SYSTEMS AND MAGNETIC RECORDERS (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
ww.	Rugged, compact storage with no rotating parts in capacity up to 10^9 bits with access times comparable to that of discs and drums.	S	8	7	71 73 80
xx.	Inexpensive low cost semiconductor memory to replace high performance drums (10^7 bits).	N/A	5	5	72 75 78
yy.	Core memories will cycle at .25 μsec. at a cost of 10-15% more than present .5-.65 μsec. core memories.	N/A	8	8	69 70 71
zz.	A new memory element will be developed which lends itself to batch fabrication and will exhibit operating speeds comparable to core memories--possibly capable of coincident current selection, thus reducing quantity of core memories.	N/A	5	5	70 72 75
aaa.	Large-scale integration techniques will be developed to become competitive with some present-day applications of core memories.	S	6	7	69 70 71
bbb.	The demand for NDRO memories will increase due to extreme environments, etc. Thus, some emphasis on memories will be steared away from present-day coincident current memory systems.	N/A	6	6	70 72 74
	(1) Plated wire and thin-film memory systems will be developed further to exhibit better performance and yield characteristics.	S	6	8	70 71 72
	(2) Laminated ferrites and/or frequency drive films and core will receive more attention.	S	5	5	71 72 75
	(3) Transfluxor or Biax system will serve immediate need for some users of NDRO memories until a significant price reduction of the more elaborate systems is obtained.	S	5	8	67 68 69
ccc.	Present-day read-only memories will be replaced by NDRO wire memories in the fourth generation due to cost performance advantages of plated wire.	N/A	5	8	72 73 74
ddd.	Single crystal ferrites will be the primary recording head materials for in-contact disc and drum memories.	N/A	5	5	70 72 75

CATEGORY - 6. MEMORY SYSTEMS AND MAGNETIC RECORDERS (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
eee.	Substantial investments will have to be made by the industry to automate memory core and plated wire mfg. to obtain lower costs as eventually foreign labor sources will become too costly.	N/A	6	5	71 73 75
fff.	Large-scale (10^{12} bits) optical memories for information retrieval (i.e., automated microfilm files).	N/A	8	8	70 73 74
ggg.	Laser devices will be used as computer fixed storage.	N/A	5	5	71 73 77
hhh.	Use of high-speed and read only memories (10.0 NS) with simultaneous access by multiple processors for micro-programming of large-scale computer systems (external).	N/A	5	5	71 73 77
iii.	Large capacity (10^{10}-10^{11} bit) optical memory to be used as a special purpose peripheral device - such as associative memory, character recognition - under the control of a digital computer.	N/A	7	5	71 72 74
jjj.	Storage systems based on holography in photochromic materials (such as KBr) used for files, libraries. Automatic rapid retrieval provided.	N/A	5	5	70 72 74
kkk.	Semiconductor memories will remain prevalent during the short-range future.	S	5	5	68 72 75
lll.	10^{15} bit memories at 10^{-7} cents per bit may be possible.	N/A	5	5	75 80 82
mmm.	Large memories (perhaps hierarchies of memory) will be shared by many computers.	N/A	5	5	71 73 75
nnn.	"Do it yourself" read only memories can be prepared with checked out programs.	N/A	5	5	72 75 80
ooo.	The need for memories as large as 10^{15} bits will be realized.	N/A	5	5	70 75 77
ppp.	Erasable medium sensitive to light and capable of controlling light. Writing times below 10 ms. This includes improved photochromic materials and magneto-optic films such as manganese.	N/A	8	5	70 72 76

CATEGORY - 6. MEMORY SYSTEMS AND MAGNETIC RECORDERS (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
qqq.	Extension of multiple head towards use of one-header-track in discs and drums.	N/A	8	5	70 72 76
rrr.	Data naming (in hardware) rather than data addressing. A system currently proposed at the University of Manchester speaks to this problem. Experiments conducted at U of P have indicated in working associative memory systems, that the decrease in programming time is marked. The chief opportunity for radical change in this area seems to be microprogramming.	N/A	8	6	70 73 76
sss.	As the sophistication of use of data processing systems increases, there will be a corresponding increase in sophistication of application. Bulk storage requirements will increase at a greater than proportionate rate as applications become more varied.	S	9	9	70 73 75
ttt.	Bulk memory will be competitive with magnetic tape in storage cost, and available in essentially infinite quantities.	M	8	4	75 78 80
uuu.	Large storage devices will provide substitute for "document" input or output.	N/A	8	5	75 80 85

CATEGORY - 7. PERIPHERALS

EVENT	Goal	Desirability	Feasibility	Timing
a. Hard-copy devices (known as first-generation types) such as teletypewriters, electric typewriters, and high-speed printers will continue to have a cost advantage (probability decreases with time).	N/A	3	5	75 73 70
b. Paper tape equipment will:				
(1) continue to be widely used, but speeds will peak at about 1,500 characters per second.	S	5	5	71 72 74
(2) gradually be replaced by direct input of data.	N/A	5	5	73 74 77
c. Conventional card reading speeds will peak at 1,500 to 2,000 cards per minute.	N/A	4	5	70 73 74
d. Punched cards will remain popular during the immediate future. However, punched cards will reach their peak as an input medium and thereafter diminish in importance.	N/A	4	7	69 73 76
e. Cards will be substantially reduced as an input medium.	N/A	5	6	71 75 78
f. The costs associated with card and perforated tape equipments may not be economical in the light of advances in such media as incremental magnetic tape recorders.	S	7	7	70 72 75
g. Rather than striving for further advances in speed, manufacturers will improve first generation peripheral equipment reliability through reductions in the number of moving parts.	S	9	7	71 74 77
h. The utilization of card and paper tape equipments will continue to decline in large-scale operations.	N/A	3	5	70 72 75
i. Wide-spread use of source data automation devices.	S	6	8	70 72 77
j. More peripherals will contain memories.	N/A	5	6	69 70 71

CATEGORY - 7. PERIPHERALS (Cont'd.)

EVENT	Goal	Desirability	Feasibility	Timing
k. Information processing for machine tools and other types of peripheral equipment common and controlled from central data stores.	N/A	5	5	78 84 90
l. Acoustically coupled peripheral devices (low cost, portable, and inexpensive) will be used for personal computation. Terminals may even be rented for short periods of time to be used in the home.	N/A	5	6	70 73 76
m. An attachment developed so that the future common typewriter will be capable of being coupled to a computer for input our output of data.	N/A	5	5	70 72 74
n. Low-cost lower performance peripheral equipments will be developed for use with small low-cost computers.	S	8	5	69 70 72
o. Low-cost 500 lpm printer terminal (non-mechanical).	N/A	8	5	70 72 73
p. Electromechanical devices will be phased out in large-scale computer applications.	M	9	8	75 81 87
q. Solid-state replacements will be developed for most functions now performed by electromechanical I/O devices.	M	8	5	72 75 78
r. Increased use of terminals, mass storage, on-line keyboard input and data capture on-line at the source will reduce future use of conventional peripheral equipments.	S	8	8	71 73 75
s. Incremental magnetic tape will replace punched paper tape in many applications.	S	5	8	69 71 74
t. Conventional punched cards will remain in use for the next ten years.	N/A	4	4	72 75 85
u. Throughput speeds will have reached their peak by means of highly perfected air-film technique. Estimate 1,000 cards/min. using electro-optical sensing.	N/A	5	7	68 70 72
v. Specialized applications will use new style magnetic card materials at still higher speeds (2,000 cards/min.), and greater character density/sq. in., (a gain of another factor of 50-75).	N/A	6	6	69 71 73

CATEGORY - 7. PERIPHERALS (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
w.	Peripherals capable of accepting technical data recorded on standard I/O media and producing graphics quality technical reports will come into wide-spread use.	N/A	8	8	72 75 78
x.	The marriage of laser devices to information processing and peripheral equipment will continue.	N/A	5	5	72 76 80
y.	Throughput speeds on paper tape will be improved by a factor of 3 due to better material and handling facilities. Character density will double by going to smaller perforation or entirely to photo-electric mark-sensing. Sprocket holes will be replaced by capstan-drive and clocking marks will be printed on backside tape.	N/A	3	3	71 72 75
z.	Both sides of paper tape and card stock will be applied for multi-purpose use in order to expand capacity of data storing. Readout to be dual-channel, possibly transmitted by multiplexing.	N/A	4	2	72 73 75
aa.	Key punching will be avoidable.	M	8	5	68 76 88

CATEGORY - 8. MICROFORMS AND RELATED EQUIPMENTS

	EVENT	Goal	Desirability	Feasibility	Timing
a.	High resolution TV viewers will come into being, providing the flexibility of electronic magnification variation and aspect ratio control to give a user a "universal" viewer for a wide variety of optical format microfilms.	N/A	8	6	71 72 73
b.	Although a substantial portion of micro-recording (such as technical reports and drawings) will be on cards for optical storage, the principal base for facsimile storage will be non-card mediums. Special "self-loading, non-rewind" cameras will assume a major role.	S	5	7	68 69 71
c.	High-quality reproduction of final drawings and management charts from image files, with high resolution, low cost, and the new flexibility of updating.	S	7	5	70 72 74
d.	The use of microforms and associated equipment is expected to increase by a factor of ten.	M	5	8	72 78 82
e.	Marriage of microforms with other information processing equipment will continue to increase the utility of microform from only a storage medium to a dynamic and important element in active current systems.	M	9	7	73 75 78
f.	Developments in electrostatus and special printout papers will lead to the production of good manual and automatic printout equipments. This will be accompanied by substantial reductions in the unit print cost.	N/A	7	8	72 74 76
g.	It will be found in many cases that microfiche is a better medium than roll film for a particular application. A converter will be designed for converting from roll to microfiche. If a system in which this is used proves practicable, it is likely that this type of conversion may increase. Improved techniques and materials as well as equipment may make it entirely practical to go to high reductions satisfactorily and we will convert from one medium to another. Much of the conversion may come as a result of greater standardization of equipments and film formats.	N/A	8	8	72 74 76

CATEGORY - 8. MICROFORMS AND RELATED EQUIPMENTS (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
h.	Substantial improvement can be expected in light sources, both for making and using film.	N/A	8	3	75 80 85
i.	Microforms will become important input media.	S	6	6	70 72 74
j.	Technology will develop the ability to "correct" microform images by erasing and reprinting on the same frame. (A camera from Pfaff is available to do this on Kalver.)	S	8	5	70 72 74
k.	Images may be added to blank spaces in microforms.	S	8	6	70 72 74
l.	New image formats will provide substantially increased coding capacity or automatic selection of images.	M	8	8	70 75 80
m.	Combination of digital and photograph (e.g., microfilm) storage and retrieval techniques will become a significant field.	S	7	8	70 72 74
n.	Microfilm recording systems will utilize instant photography.	N/A	6	6	70 72 74
o.	A simple low-cost device will be available for copying materials on the spot. This concept will be made possible by dry process films.	N/A	7	7	71 74 80
p.	Microform printers will be capable of printing in color.	N/A	8	7	72 74 77
q.	Microfilm viewers will be used for displaying in color.	N/A	8	8	68 70 72
r.	Microfilm recording systems could utilize laser writing ability.	S	5	7	70 72 74
s.	Composition of graphic arts material could be computer prepared, e.g., on microfilm or larger film sizes (depending upon the desirability of being able to mask, touch, or refurbish).	S	5	6	70 71 72
t.	We can look forward to substantial improvement in the quality of microfilm and microfilm equipment. Departures from conventional lens design practices can be expected; some specific improvements in film characteristics and new types of films can be expected. More compact and manageable equipments will be available. Substantial improvements will be made in the reproduction area.	N/A	5	5	72 75 80

CATEGORY - 8. MICROFORMS AND RELATED EQUIPMENTS (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
u.	Video film will be a competitor for microfilm.	N/A	5	3	75 85 80
v.	Microform files may compete with and/or supercede the use of TV consoles for info retrieval from numerous banks of information.	N/A	5	8	67 70 68
w.	Still higher density microforms (linear reductions of 1000/1 to 10,000/1) will be developed.	N/A	3	5	68 70 69
x.	Better application of current materials and technology will be made with respect to density of info recording.	N/A	5	5	69 72 70
y.	Compact, less expensive viewers will result from a breakthrough in optics design.	N/A	8	4	70 75 73
z.	Economical holograms rapidly prepared by computer.	N/A	5	3	74 83 77
aa.	Large-scale production of microfiche (currently available).	N/A	8	8	N/A
bb.	Low-cost microfiche production equipment.	N/A	8	5	70 76 73
cc.	Professional literature dissemination in microform.	M	8	5	73 79 76
dd.	A magnetic stripe on roll film or a strip across a microfilm chip or a strip across a piece of microfiche may make it possible to search very easily and rapidly and in some cases be more efficient than optical coding (prevents optical scanning).	N/A	3	3	N/A
ee.	There will be available simple conversion equipment which would allow libraries to convert in mass from 35mm to 16mm film.	N/A	5	8	70 73 71
ff.	Image size can be adjusted to be compatible with the selected recording process.	N/A	3	8	70 77 74
gg.	Low-cost CW lasers with the proper characteristics for selected, commercially available recording media.	N/A	5	5	71 75 73

CATEGORY - 8. MICROFORMS AND RELATED EQUIPMENTS (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
hh.	General user acceptance of high density microforms.	N/A	5	8	74 76 78
ii.	High-quality micro-medium for storing information of permanent value (but low usage rate) in a manner capable of direct input to computer.	N/A	8	8	71 73 75
jj.	High-quality micro-medium for important information not to be erased or altered, also machine readable.	N/A	8	8	71 73 75
kk.	There will be a radical change in the policy and methods of publication. Copyright laws are a chief obstacle to wider publication in microforms, and publishing houses are struggling with the problem but with an eye very solidly on the possibility of microform publications.	N/A	7	5	72 74 77
ll.	New technology for continuous channels of micro-miniaturized digital data so that extensive "spooling" of the medium can be eliminated.	N/A	5	5	69 72 75
mm.	Use of wave pattern on micro-miniaturized mediums for digital machine-readable data, providing inexpensive long-term storage with minimum of daga loss.	N/A	8	8	69 71 73
nn.	There is an extremely great need for a revolutionary new type of micro-film reading device. It should be as easy or easier to use than a book, portable, and can be read leaning back in a chair. You should be able to take it to bed with you if you like. The system surrounding it should be one which will allow the user to carry with him, or have at his disposal, large amounts of information.	N/A	5	3	73 75 80
oo.	Information automatically retrieved aperture cards can be updated and re-recorded using computer aided operation on new records. Turn around time will be a few minutes.	S	5	6	70 72 75
pp.	Use of conventional printed materials will decline, and be replaced by high density media and soft display.	N/A	2	1	78 80 87

CATEGORY - 9. FACSIMILE AND REPRODUCTION EQUIPMENT

EVENT	Goal	Desirability	Feasibility	Timing
a. Facsimile devices will be utilized at an increasing rate for security applications.	S	5	5	71 73 77
b. The marriage of facsimile devices to other information processing equipments will be a continuing trend, such as operating on line with a computer or interfacing with microform systems.	N/A	6	7	70 75 78
c. The use of facsimile devices will increase to such an extent that scanners and printers may become common office equipment.	M	5	7	73 77 80
d. The major growth of the facsimile market can be in low cost general purpose systems.	N/A	7	8	74 77 80
e. Microfilm transmission to microfilm will be feasible, but only practical in situations where urgency of data need warrants the high transmission costs incurred.	N/A	4	8	67 68 70
f. Pantograph systems can be used to transmit signatures and sketches over voice grade telephone lines.	N/A	5	7	72 76 80
g. A portable document copier will be in common use.	N/A	5	7	70 72 74
h. Combined facsimile and acoustic signals (i.e., electro-cardiographs) with phone line couplers can be developed.	N/A	5	5	73 77 80
i. Microfilm transmission to hard copy.	N/A	4	5	69 71 73
j. Light sensitive (ultra-violet and non-u-v) paper and film which does not require wet processing will be widely used for hard copy, etc. in quiet, non-impact, high speed, terminal and peripheral equipments. Some of the materials will have instant image formation and may require heat or light for fixing; other materials will require a dry auxilliary step for simultaneous latent image development and fixing. The materials will have wide grey scale range and high resolution.	N/A	7	6	70 73 76

CATEGORY - 9. FACSIMILE AND REPRODUCTION EQUIPMENT (Cont'd.)

EVENT	Goal	Desirability	Feasibility	Timing
k. High-speed, photosensitive, non-chemically developable paper for hard copy recording.	N/A	8	8	69 72 74
l. The conversion of electrical signals to hard copy will be considerably improved by the availability of high power electro-optic transducers, and the development of electro-sensitive papers and other marking processes.	N/A	8	4	70 72 74

CATEGORY - 10. LONG DISTANCE COMMUNICATION

	EVENT	Goal	Desirability	Feasibility	Timing
a.	In land communications, analog transmission for high-speed, high-capacity systems will be replaced by digital transmission.	S	6	6	71 74 78
b.	In satisfying the need of landline requirements, very short-haul needs will be satisfied by analog and digital source signals.	N/A	5	5	69 71 74
c.	Eventually, a visible light channel will be able to pass approximately 10^4 T4 channels through the medium of air or outer space.	N/A	5	5	74 78 84
d.	Operating in an air or outer space medium, one visible light transmission system, utilizing the digital systems of T1 through T4, will be able to handle 2.10^6 T1 channels, or approximately 3.10^6 megabits per second.	M	5	6	75 80 88
e.	TV cables could provide an inexpensive alternative medium for long-distance graphic and digital communication.	M	5	6	72 76 80
f.	Communication networks will be shared by facsimile and data terminals.	N/A	5	4	72 75 80
g.	Expanded use of private transmission systems; microwave; coaxial cable and wire for transmission within plant complexes/metropolitan areas.	N/A	5	8	69 71 74
h.	Domestic transmission via satellite will provide band-widths essential for efficient computer-computer transmission.	M	5	5	71 75 82
i.	Fiber-optic techniques applied to laser beam transmission will provide a new source of broad band-width, short distance communications channels.	N/A	5	5	72 80 85
j.	Broadband (19-240. kilobit) transmission will be widely available within the continental U.S. switched networks.	N/A	6	8	70 75 78
k.	Provisions for high speed data communication lines which can be connected to a remote mass storage (~20 MS. access) to handle emergencies when the local mass storage is defective.	N/A	5	4	73 75 80

CATEGORY - 10. LONG DISTANCE COMMUNICATION (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
l.	Narrow-band by elimination of redundancy in image transmission (down to 4 megabits/sec).	N/A	6	4	71 72 73
m.	Subscriber connection to T1 facilities in efficient manner utlilizing full digital capacity of local loop.	N/A	8	5	70 72 75
n.	The public telephone network will become all digital.	N/A	5	5	80 85 90
o.	Inclusion in the coming Digital Communications System backed by computers, the capability to handle two level digital graphic communications and also tone shaded graphics in its analogue signal form.	N/A	6	8	69 70 72
p.	Digital message-oriented data network utilizing store and forward techniques to permit many computers to converse. Message delays should only be a fraction of a second, and reliability should be very high.	N/A	8	5	70 72 74
q.	Charges for use of public telephone network based on access (number of calls) rather than time and distance.	N/A	4	6	72 75 80
r.	Transmission charges based on distance and bit rate as well as time,i.e. based on data volume transferred.	S	6	8	69 73 76
s.	Serial techniques for data communication between computers, and between computers and peripheral devices.	N/A	5	7	70 72 75
t.	Systems permitting isolation of errors in transmission to either terminal systems or communication systems.	N/A	8	5	70 73 80
u.	Dial-a-document and remote delivery over low-cost line from automatic S & R Systems. Political action is required to make low-cost lines available.	S	8	7	71 74 76

CATEGORY - 11. SOFTWARE

	EVENT	Goal	Desirability	Feasibility	Timing
a.	There will be a sequence of small languages relating small groups of people to machines, and groups of machines. This comment is based on the promise that, for example, there is no need to force physicists to talk the same language as biologists.	N/A	5	5	69 75 80
b.	Compiler-compilers which will include front and back end languages (permitting code optimization) will be the normal technique for producing compilers.	N/A	5	5	69 71 73
c.	Machine indexing of both textual and pictorial data.	N/A	5	4	72 76 80
d.	Compilers will provide an object program as good as a hand-coded program	S	6	6	70 72 74
e.	Programs will become more modular. Combinations of program packages can be made to solve specific problems.	N/A	5	5	72 74 77
f.	Natural English language for file inquiry and updating.	N/A	8	4	74 76 85
g.	A universal computer language will have evolved through automated communication.	N/A	2	3	85 95 2050
h.	Modular technologies will be utilized in industrial research and development efforts. In other words, programs will be developed in theory and placed on tape. Combinations of machines and computers will be utilized to determine the practicality of various combinations in an effort to accomplish the objective of the program.	M	6	4	74 76 80
i.	Sub-routine libraries will become more general, i.e., library routines more like generators than fixed procedures.	N/A	8	8	69 70 71
j.	For new, more exotic application, software cost will substantially increase. Conventional business and scientific application can make greater use of software systems supplied by the hardware manufacturer as part of the library package.	S	4	6	70 73 76

CATEGORY - 11. SOFTWARE (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
k.	Availability of "canned" specialized software packages designed to "run" on any computer.	N/A	5	5	70 73 76
l.	"Machine-independent" languages will be in wide use. Each machine will begin to have a "life" of its own in terms of its own environment.	M	8	6	72 75 80
m.	Machine-independent operating systems will be perfected, yet each machine will have different local behavior.	S	8	4	70 71 72
n.	Code optimization techniques will be available producing object code more efficient than is possible by most human programmers.	N/A	8	5	70 74 78
o.	Cheap, "accurate" indexing of natural language text.	N/A	5	5	72 74 76
p.	Assembly language will become obsolete as far as the "user" is concerned.	S	8	6	70 72 75
q.	Various compiler level languages will be developed for specialized applications.	S	8	6	68 69 71
r.	Verifying compilers will make formal proof that each program will operate as intended. Proof may be aided by "intent" statements throughout code. Systems will be capable enough to prove complete executive systems error free and secure. May be a prerequisite to security certification.	S	8	5	71 74 77
s.	Development of high level functional languages facilitating more direct communications between the user and the data bank. However, effective communication will not be possible for some time.	S	8	6	70 72 75
t.	Greater adaptability and flexibility to accommodate special user requirements through the use of formal modular software structure. Requires that the entire system of computer usage be rethought and redesigned.	M	6	4	72 75 78

CATEGORY - 11. SOFTWARE (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
u.	Data naming (in hardware) rather than data addressing. A system currently proposed at the University of Manchester speaks to this problem. Experiments conducted at U of P have indicated in working associative memory systems, that the decrease in programming time is marked. The chief opportunity for radical change in this area seems to be microprogramming.	N/A	7	5	70 73 75
v.	Indexing schemes will be improved to permit retrieval based upon a wide variety of information characteristics. Frequest reindexing by computer will become more important.	N/A	9	5	68 69 70
w.	Capitalization of past software investment, i.e., using past computer's software when going to new system and using other manufacturers' computer software directly on a next generation computer.	M	6	5	75 79 83
x.	Development of software and languages necessary to permit close man-machine interaction and to facilitate use of display terminals by casual users rather than skilled operators.	S	8	8	71 73 75
y.	75% of all programs will be machine independent. Technically, this can be made feasible after a concerted effort to make the machine accept a different type of program. Politically and economically, this requires planned R&D and a purchasing effort that would force a complete change in the machine usage pattern.	M	8	6	72 75 78
z.	Machine assisted debugging.	N/A	7	9	69 71 75
aa.	Compiler generating compilers will facilitate a proliferation of customized applications-oriented languages.	N/A	8	8	69 71 75
bb.	Use of Meta compilers - *Dynamic* language specification. Contemporary experience has shown that more effective application by users requires an extensive education program for both manufacturer personnel and computer installation personnel.	N/A	8	6	70 74 76
cc.	Modular and implicitly programmed software.	N/A	6	4	70 72 74

CATEGORY - 11. SOFTWARE (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
dd.	Natural syntax is badly suited to computer use because it requires sophisticated knowledge of context to resolve ambiguities. Restricted "quasi-natural" syntax is a likely precedent to natural syntax.	N/A	7	5	72 74 77
ee.	Advances in software will have a more significant effect on use of graphics in man/machine context than hardware.	M	9	8	70 75 80
ff.	Computers will accept and learn the <u>syntax</u> of artificial and then natural language by receiving a sample set of strings that belong to the language, and sets of strings that do not belong to the language. (This has already been achieved, for example, at the Moore School for certain classes of languages.)	N/A	8	8	69 69 70
gg.	Computers will accept and learn the <u>semantics</u> of artificial and then natural language by receiving <u>correlated</u> sets of strings that describe the <u>equivalence</u> between certain strings and symbols, thus developing automatically the <u>meaning</u> of a language from the information that is put in from outside.	N/A	8	5	71 73 75
hh.	Research identifying technical and cultural linguistic communities within a natural language, with a view to simplifying man-machine intercommunication by specifying the linguistic environment.	M	5	5	75 80 85
ii.	Research in theoretical linguistics that will eliminate the motion waste in conversational modes of man-machine intercommunication, by improving the techniques for processing natural languages.	L	8	5	80 85 95

CATEGORY - 12. COMPUTER ORGANIZATION

EVENT	Goal	Desirability	Feasibility	Timing
a. Development of standards for symbolizing large scale integrated circuits and large scale modules.	M	5	5	72 75 80
b. <u>Airborne or Shipborne Computers</u>, used in real time control or scientific computation could have the following characteristics:				
(1) Heavy use of LSI (Large Scale Integration)	S	9	9	71 75 78
(2) Heavy use of MSI (Medium Scale Integration)	S	5	5	69 71 74
(3) Built in floating point arithmetic by hardware	S	7	9	68 70 72
(4) Use of hardware scratch pad	S	7	7	69 70 72
(5) Built in associative processing	S	6	8	72 74 78
(6) Switch from analog to digital sensors	M	8	9	73 78 84
(7) MIC A/D to D/A Conversion	M	8	4	72 75 80
(8) More special purpose processors because of LSI for very high volume applications.	M	4	5	73 76 84
c. Computers that allow language to be dynamically specified.	S	7	8	70 73 76
d. Built-in self-reconfiguration by selecting redundant parts.	M	9	4	73 75 80
e. Computer architecture may have the following features:				
(1) variable bandwidth communication interfaces and control	S	9	9	70 72 73
(2) data handling and manipulation	S	9	9	72 74 75
(3) variable data descriptions	S	9	5	74 76 77

CATEGORY - 12. COMPUTER ORGANIZATION (Cont'd.)

EVENT	Goal	Desirability	Feasibility	Timing
(4) variable operator descriptions	S	9	9	69 72 73
(5) equipment upgrading without reprogramming	S	9	5	68 71 72
(6) hierarchical memory management	S	9	5	70 72 73
(7) executive control functions	S	9	9	72 74 75
(8) parallel processing.	S	9	5	68 72 73
f. Processors designed to perform certain functions efficiently, e.g., Fourier transforms, associative retrieval, will be available for incorporation as modules into general purpose computer systems.	S	9	5	72 74 75
g. Canonic representation of hardware-software systems to permit computer aided manipulation of these complex systems.	N/A	8	8	72 73 74
h. Computers will be built using read-only memories to implement substantial portions of software in hardware reducing programming costs for users.	S	5	7	69 71 73
i. LSI will lead to the realization of functional memories, i.e., logic-in-memory, which will impact the basic design philosophy of computers.	N/A	5	5	71 73 75
j. Additional hardware sophistication will minimize software requirements while handling more input/output data with no sacrifice in throughput. This would require a concerted systems effort. The hardware structure of existing computers would have to be changed through techniques such as micro-programming.	N/A	8	4	74 78 80
k. User will have his choice of performing many functions either in the hardware or as programmed in the software.	S	8	5	69 72 75
l. Low cost business data distribution via satellite will provide world-wide pricing, inventory data, etc.	M	5	5	72 76 82

CATEGORY - 12. COMPUTER ORGANIZATION (Cont'd.)

EVENT	Goal	Desirability	Feasibility	Timing
m. Special functions within a computer will be implemented in micro-logic so that programming will be simplified and maximum efficiency obtained. The micro-logic will make use of multiple levels of internal storage, read-only memory, associative memories and yet-to-be developed memory techniques. Phase 1 of this development is here. Phase 2 will see "special purpose" computers (e.g., payroll computer, production control computer, fortran computer) available utilizing completely common hardware.	M	8	5	72 75 78
n. Computer aided logic design will enable the system designer to formulate, evaluate and optimize his proposed design without going through the "breadboard" stage.	S	6	4	68 70 72
o. Parallel organized computers will offer several orders of magnitude speed advantage over conventional computers. This speed advantage will be used to investigate problems too large for conventional computers, in the areas of simulation, automation, hydrodynamics, signal processing, fluid mechanics (weather forecasting), plasma (with applications to the designs of devices for controlled thermonuclear reactions), and a factor of at least 100 compared to the fastest conventional machines presently available. ILLIAC IV represents the first of such systems. ILLIAC IV is scheduled to be operating by mid-1970. Other design philosophies should be thoroughly investigated.	S	8	8	70 72 75

CATEGORY - 13. SYSTEMS AND APPLICATIONS

EVENT	Goal	Desirability	Feasibility	Timing
a. Navy computer networks which can interchange information with other remotely located computers over communication links, such as the process of letting bids on a job (i.e., reducing it from months to hours).	N/A	6	7	70 71 73
b. Artificial intelligence - computers that learn, think, create, etc.	N/A	5	3	78 85 90
c. Man-connected computer systems in common use for control of eye movement, muscle or brain waves.	N/A	2	4	75 84 90
d. A large number of small computers on-line with a central system will become commonplace.	N/A	5	5	71 75 79
e. Small modular computers will be built into experiments as part of the control or data acquisition system.	N/A	5	8	68 72 76
f. In many system purchases, components will be obtained from different manufacturers, e.g., main frame from manufacturer A, memory from manufacturer B, peripherals from other manufacturers, etc.	N/A	5	8	69 70 72
g. The advent of watch-like computers will change the requirements for central time-shared machines and turn them into message switchers, large remote batch systems and libraries.	N/A	5	5	74 78 81
h. The advent of watch-like computers will radically change our views of present communication, information handling, displays and data capture. In fact, they may become the prime terminal.	N/A	5	5	74 78 81
i. High storage-density optical media for information storage and retrieval with variable magnification viewing and insertion of data into video displays will be available (i.e., microfilm = microphotographics).	N/A	6	8	68 69 70
j. Centralized blue print files using film chips will become feasible. Chips will be retrieved automatically, scanned and relayed over wide band lines.	N/A	6	5	69 70 72

CATEGORY - 13. SYSTEMS AND APPLICATIONS (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
k.	Widespread use of graphics systems for management and planning. Display consoles available to managers and their staff providing access to the accumulated information resources of the country.	M	8	5	71 75 80
l.	Widespread use of computer aided design techniques for structures, ships, planes, autos and component parts.	S	8	8	69 71 75
m.	Widespread production of motion picture and TV for both education and entertainment utilizing computers for both design and display.	N/A	5	7	71 75 80
n.	On-line color TV will permit computer user to "tune-in" and follow the course of his problem in real-time.	N/A	5	5	75 80 85
o.	Processing of data directly into CRT for making of movies depicting solution of problem.	N/A	6	5	70 73 78
p.	It will be possible to produce machine tool tapes directly from a graphic input station.	N/A	5	8	70 75 80
q.	Improved displays for data retrieval utilizing alphanumerics and/or graphics in an <u>application-oriented</u> format and process for ready assimilation and use by non-EDP trained functional personnel.	N/A	8	8	69 71 73
r.	As equipment costs become lower and labor costs go up, it may be expected that much wider use of point-of-origin gathering of data will occur.	N/A	7	6	70 74 77
s.	Combined analog/digital systems will appear including tape for storage and retrieval of photographic data with digital data.	N/A	5	6	73 76 80
t.	3rd generation hardware lifetime will be extended by memory extension.	S	6	7	70 71 72
u.	Systems providing access to "library" type data with hard copy output via simple electronic I/O device (direct transmission) will be operational on a local city basis.	M	6	6	73 78 81

CATEGORY - 13. SYSTEMS AND APPLICATIONS (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
v.	Low cost stored program processors will link the local retail outlet to powerful central processors for inventory control and accounting.	S	6	8	70 72 76
w.	Computers with many (thousands) remote terminals netted together across nation and world-wide doing cooperative problem solving.	M	6	6	73 75 80
x.	Library data will be available on home TV sets.	N/A	5	5	80 90 2000
y.	Low cost stored program computers with many teletypewriter terminals will serve as local message collection and distribution terminals and provide access to primary communication systems.	S	8	8	70 73 78
z.	Multi-level computer and terminal networks with some processing done at terminal, some at 1st level computer geographically close, some at 2nd level computer further away and more powerful, etc., will be developed. All processing will be done at the lowest possible level in the network to minimize communication costs.	N/A	8	8	71 73 75
aa.	Remote inquiry stations combined with television will provide over 50% of college education for engineering students.	N/A	4	4	74 78 83
bb.	Keying errors will tend to be overcome with verified pre-recorded message composers being used at remote data input stations.	N/A	6	8	69 70 72
cc.	Low error rate, human operated, remote keyboards, used with self-checking numeric systems will be used in parts ordering, inventorying, etc. in conjunction with central computer systems and DDD communications.	S	8	8	68 69 70
dd.	Video-data combinations will be recorded on magnetic cards and color image transfer to follow up to be used for instance on routine service instructions (home office - district office, etc.), intelligence work, etc.	N/A	8	8	71 73 75
ee.	Information will be universally stored on a machine readable medium, rendering recopying by hand obsolete.	N/A	8	5	68 75 85

CATEGORY - 13. SYSTEMS AND APPLICATIONS (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
ff.	Touch Tone input to remote microfilm Retrieval Systems and graphic print out.	S	5	6	69 71 73
gg.	Improved software for micro-digital recording of facsimile of printed or typed material, in the range of 100-1 reduction.	N/A	8	5	70 73 78
hh.	Drafting will be reduced to a set of codes which may be transmitted as easy as data. The engineer or the draftsman would compose a drawing in this new language and it would become as easily understood and recognizable as our present simplified drafting practices.	N/A	8	6	71 73 75
ii.	Information banks will be established on the basis of professions, types of equipment, technologies, special fields of interest, etc. They will do their searching on computer controlled basis; however, it is likely that microfilm will play a significant part in it, either as the information store or as the means of delivery of the information.	N/A	3	5	75 78 85
jj.	Instead of buying books and going to libraries for information, a student will be issued a reader and complete sets of microfilm with his entire course of study and all of the associated reading materials. The cost would be sufficiently low that the convenience to him would be worth the cost. The ability of microfilm to be distributed quickly and easily and updated would make it possible for additional materials to be handed out easily and quickly to be added to the collection in case the art is advancing or additional materials become available.	N/A	5	7	72 75 80
kk.	Use of microforms in the home will be accelerated by merchandizing in color microfiche catalogues read on home TV viewers.	N/A	5	5	72 74 78
ll.	Computer generated tapes for playback on inexpensive audio video equipment will be prevalent.	N/A	5	5	76 81 87
mm.	Digitized voice/analog transmission between central offices and switching centers to facilitate time-division multiplexing, encryption and switching.	S	6	5	71 74 78

CATEGORY - 13. SYSTEMS AND APPLICATIONS (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
nn.	Full blown time-sharing systems which provide multi-programming capability and remote terminal servicing will be available.	S	9	7	70 72 74
oo.	There will be substantial use of the on-line time-sharing computer systems which will facilitate the purchase of computing services at a reasonable price. Line costs will still be high, resulting in system costs which will prevent widespread use for some time.	S	8	6	69 70 71
pp.	Use of simulation to determine design of information storage and retrieval systems.	N/A	5	5	69 71 72
qq.	Modular, dynamically changeable command structures in on-line systems for rapid construction of easier man-machine interfaces which are particularized to individual users.	N/A	8	8	70 72 74
rr.	Man-machine capabilities to allow a user to examine in greater detail, at various levels, the output results of Management Information reports. With this would also come the opportunity to experiment more with overall results by causing changes in variables used in projecting from the bases established by using this stored information. The result would be a greater understanding by the user of the methods used to derive the information and what variables cause changes in what areas.	S	6	6	70 74 77
ss.	Management not making use of management information and control systems which are real-time current awareness call up systems will not be able to perform competitively.	N/A	5	6	70 72 75
tt.	Program restructurable systems.	S	6	5	70 72 74
uu.	User programmed systems without programmers. Programmer only used to program firmware.	N/A	4	6	73 75 77
vv.	Due to cost considerations, there will be an upsurge of remote batch processing systems which will have a depressing effect on interactive time-sharing systems.	N/A	2	1	69 71 72

CATEGORY - 13. SYSTEMS AND APPLICATIONS (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
ww.	Self-organizing software systems which given a generic description of a new capability generates new code.	M	6	3	72 75 77
xx.	Low-level machine assistance to indexing of documents.	N/A	6	5	70 73 75
yy.	80% of work running on computers will be of a synergistic/symbiotic type.	M	5	5	74 78 85
zz.	Greater tolerance for error through the use of redundancy in the input and automatic error correction.	N/A	5	5	74 77 80
aaa.	User-oriented software and terminals.	N/A	8	8	70 71 72
bbb.	Powerful question-answering systems will be developed which can assimilate thousands of facts and algorithms and efficiently develop long deductive chains of these to prove a result.	N/A	8	5	70 72 76
ccc.	Systems will be designed to give <u>both</u> rapid retrieval from, and rapid updating of, large data bases to <u>on-line</u> users.	N/A	8	5	70 72 74
ddd.	Individual hand-printed expressions will be intepreted at the speed of writing and thus permit on-line hand-written input on a practical basis.	N/A	5	5	70 73 76
eee.	With the advent of time-sharing interpreters will assume greater importance in systems, and provide simpler processing of variability.	N/A	8	8	69 70 71
fff.	Simulation will be the standard tool by which operating systems are tested, designed and constructed.	N/A	5	7	69 70 71
ggg.	Software systems will contain complete data taking subsystems so that performance can be monitored.	S	8	8	69 70 71
hhh.	Software will be recognized as a product to be treated in production, testing and maintenance like other products.	N/A	8	8	69 70 71

CATEGORY - 13. SYSTEMS AND APPLICATIONS (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
iii.	Development of machine-processable languages capable of representing and simulating the combined action of hardware and software systems at whatever level is desired, from logic elements through modules and more complex units.	M	5	7	72 77 82
jjj.	A major increase in the use of computers for simulation is predicted facilitated by major changes in the use of peripheral equipment.	S	5	9	70 72 75
kkk.	Cryptographic systems for normal business data will be in use.	M	5	9	73 75 80
lll.	Automatic adaptive dissemination of information such as selective distribution of predetermined types of data.	S	8	5	70 72 75
mmm.	An international technical data system will be in operation:				
	(1) with access by company library via electronic I/O devices.	M	7	6	75 80 85
	(2) with access by individual scientist through desk top devices.	L	9	3	80 86 91
	(3) with electronic language translation capability provided.	L	5	4	90 96 2000
nnn.	Central large computers will be available on phone lines in most large cities.	S	5	8	72 75 76
ooo.	Laboratories, as we know them today, may go out of style as experimentation by computer will be less expensive than by other methods. Laboratories may be used only to validate the research done by computer.	N/A	1	1	85 2000 2100
ppp.	Automation will have advanced farther, from doing menial chores to performing some rather sophisticated high-IQ functions.	L	8	2	74 85 95
qqq.	Complete interlocking of man and machine will be accomplished although the degree to which brain waves will be utilized is questionable; but man will be able to function as an integral part of an analog in systems sufficiently fast that the analog will make a half a dozen dry runs from which the optimum will be selected.	L	5	3	84 87 95

CATEGORY - 13. SYSTEMS AND APPLICATIONS (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
rrr.	Techniques will be perfected to isolate hardware and software malfunctions, positively.	M	8	5	70 75 80
sss.	Hardware and software purchases will be divorced.	S	4	3	68 75
ttt.	Marriage of computer-aided instruction techniques with standard information processing technology to effect error handling and reference manuals through user training.	M	8	8	72 75 72 80
uuu.	Operation of national or world-wide central data storage facility with wide access for general or specialized information retrieval.	M	6	4	75 80 85
vvv.	Office and home use of a computer utilize centralized on a city basis will become common.	N/A	4	5	75 80 85
www.	The majority of technical specialists will have access to a local typewriter terminal connected to a time-shared computer.	S	5	7	70 73 76
xxx.	Advanced communications terminals will allow many professionals to carry on their work at home, eliminating much person-to-person contact.	N/A	1	1	80 90 2000
yyy.	Need for Post Office services will decline, and be replaced by point-to-point digital transmission of information.	N/A	3	1	78 84 87
zzz.	Breakthrough in long-range weather and sea state forecasting for Naval forces at sea.	M	8	6	72 74 80
aaaa.	Automated digital in-shore environmental data bank for major harbor and beaches of the world. It would include information about the currents, bottom geomorphology, surf, salinity, turbidity, for these in-shore areas.	M	6	7	72 75 78
bbbb.	Graphic arts quality printing using computer technology will be generally used throughout the industry.	M	5	8	75 77 80

CATEGORY - 13. SYSTEMS AND APPLICATIONS (Cont'd.)

	EVENT	Goal	Desirability	Feasibility	Timing
cccc.	Development of more powerful capabilities in man-machine areas which lead, instruct and assist the user in obtaining desired results primarily via the use of CRT consoles in on-line, real-time situations.	S	7	7	70 75 77
dddd.	Personal terminals which "simulate" routine activities of employees in functional departments (e.g., personnel, contract administration, pricing, etc.) so as to increase productivity of administrative work.	M	6	4	74 76 80
eeee.	90% of the documentation required to manufacture an electronically based product will be computer generated in an acceptable format. Complete electrical documentation from logic designer at a terminal.	M	7	7	70 75 80
ffff.	Micro-electronic and medical technologies will reach the point where it will be possible to directly stimulate (by implantation or other means) the appropriate areas of the human brain in order to produce sights and sounds as an aid to the blind or deaf.	L	5	3	85 90 2000
gggg.	The need for higher speed systems will continue to grow. Such systems will be designed and built.	N/A	5	5	69 72 75
hhhh.	The use of computers in the educational process will expand rapidly and significantly.	S	8	8	69 72 75
iiii.	Powerful capability will exist for modeling computer programs and computer systems such that predictions of "goodness" of computer hardware and software systems can be made <u>reliably</u>.	N/A	8	5	69 72 80
jjjj.	Computers will receive signals from radar sets, physical experiments, sensors, etc., and begin to organize them into meaningful structures.	N/A	8	5	73 75 77
kkkk.	A major increase in the use of small central processors suitable for procurement by individuals to perform such functions as climate and lighting control in the home, systematic information retrieval from various sources such as stock brokers, banks and retailers and scheduling of such functions as maintenance, budgeting and medical care.	M	7	6	72 78 84

CATEGORY - 13. SYSTEMS AND APPLICATIONS (Cont'd.)

EVENT	Goal	Desirability	Feasibility	Timing
1111. Operating systems which integrate executive, generalized data management, and programming languages will become operational.	N/A	8	6	69 70 72

CATEGORY - 14. STANDARDS

	EVENT	Goal	Desirability	Feasibility	Timing
a.	Develop commonality and compatibility of various graphic communications gear, weather reception and transmission gear, instrumentation display equipment such as Sonar, Automatic Picture Transmission (from Satellites), Computer Print Out, etc., toward alternate end use, back up capability, common parts, servicing, training, and to a degree operation	S	7	5	69 70 72
b.	Standard programs for use on computers used in collecting, editing, distributing and forwarding messages will minimize programming costs of computer terminals.	N/A	8	8	70 75 80
c.	A comprehensive standardization program covering character sets and codes, input/output media, transmission control procedures, data elements and their codes. This will tend to reduce costs and tend to produce compatibility of computers and terminal device.	N/A	8	8	71 73 78
d.	Universal punched card specification will be promulgated.	N/A	6	6	69 70 73
e.	Development of a satisfactory code for punched cards that is easy to convert, both to ASCTI and current card codes.	S	8	5	69 71 73
f.	Microform film sizes and types will be standardized, as well as product terms. 40X or 8mm image will become predominant.	N/A	7	7	69 73 76
g.	It has been established that there are substantial advantages in exposing microfilm to get the optimum relationship between line density and background density. Both manual operation of printers and automatic printout processes would benefit greatly because the exposure setting for these devices can remain fixed and an optimum print will be forthcoming at a single setting. There will be equipment designed to make this as simple as the present method and recover substantial savings to those making prints from microfilm.	N/A	5	3	69 70 72
h.	Establishment of standards for alpha-numerics and drawing lines for enhancement of the transmission of graphics to remotely located stations.	N/A	8	8	68 69 69

CATEGORY - 14. STANDARDS (Cont'd.)

EVENT	Goal	Desirability	Feasibility	Timing
i. Some problem-oriented languages will be standardized.	S	6	4	70 73 76
j. Compatibility of special purpose military computers - program compatible with commercial data processors.	N/A	8	6	71 72 75
k. There will be greater standardization of data systems and procedures in order to use standard software and programs in conventional type business operations.	N/A	5	5	72 75 80
l. Standard methods of describing technical data on standard I/O media for automated graphic quality printing will be developed.	N/A	8	8	70 72 75
m. The acceptance and use of a Universal Personal Identification Code (UPIC) for the unique identification of individuals.	M	4	6	72 80 85
n. Development of OCR standards compatible with both upper- and lower-case characters.	N/A	5	8	70 72 75
o. Development of standards for representing graphic data and displays by digital means, including machine-tool control.	M	5	5	75 80 85

CHAPTER IV

OPERATIONAL IMPLICATIONS

A. Description of the Model

This Chapter graphically describes highly probable effects on information-processing users (particularly Navy users) of the technological advances projected in Chapter III. The goals discussed in Chapter I and Chapter V are here related to the forecast using a graphic format. Consideration is given to such important factors as effectiveness, manpower requirements, training, and operating efficiency, as well as the implications (from the user's point of view) of new products, profits, economics of scale, and market share. Stress is placed on demonstrating how information-processing technology can be capitalized on by the user - specifically, the U. S. Navy.

The relevance tree model used segregates the events listed in Exhibit 4 of Chapter III into goals and supporting events.

1. Goals - Goals have been classified as short-range, mid-range, and long-range. Each goal is designated by a square. The number/letter combination identifies the event designated as a goal by category and item as they appear in the ordered event list of Chapter III.

2. Supporting Events - Supporting events have been classified as necessary (essential to goal accomplishment), or as desirable (enhancing accomplishment). Each necessary supporting event is designated by a triangle, while each desirable supporting event is designated by a circle. The number/letter combination identifies the supporting event by category and item as they appear in the ordered event list.

3. It should be noted that the appearance of an event as a goal in one model does not preclude its appearance elsewhere as either a goal or supporting event or vice versa. Short-range goals may be considered as either events extremely necessary to the accomplishment of mid- and long-range goals or as providing essential assistance in the form of fallout. Failure to provide the capabilities represented by earlier goals will delay or even frustrate the accomplishment of follow-on goals.

This Chapter basically consists of a series of models designed to demonstrate interrelationships between the events cited in Chapter III. The author's conceptualization of how these models might be used is illustrated in Exhibit 1. A long-range goal was selected and a pathway was traced through intermediate goals and supporting events back to current technology. Several sample events have been extracted from the ordered list appearing in Chapter III. They appear in synopsized form in the exhibit to demonstrate the meaning of the codes appearing in the geometric forms. The number represents the category from which the item was selected (e.g., category 3, Computers and Calculators). The letter(s) represent(s) the particular item selected from within the category ordered listing (e.g., item mm).

These relevance tree models have been constructed based upon the structuring activities carried out by the Round II panel of experts. Each expert was asked to designate major events and then (as if he were standing in the future and looking backward in time) to list those events necessary or desirable to the accomplishment of each major event. Detailed statistical analysis has enabled the author to prepare a series of integrated models offering a series of goals with normative tracings indicating how they can be accomplished. These individual models appear on pages 107 through 153.

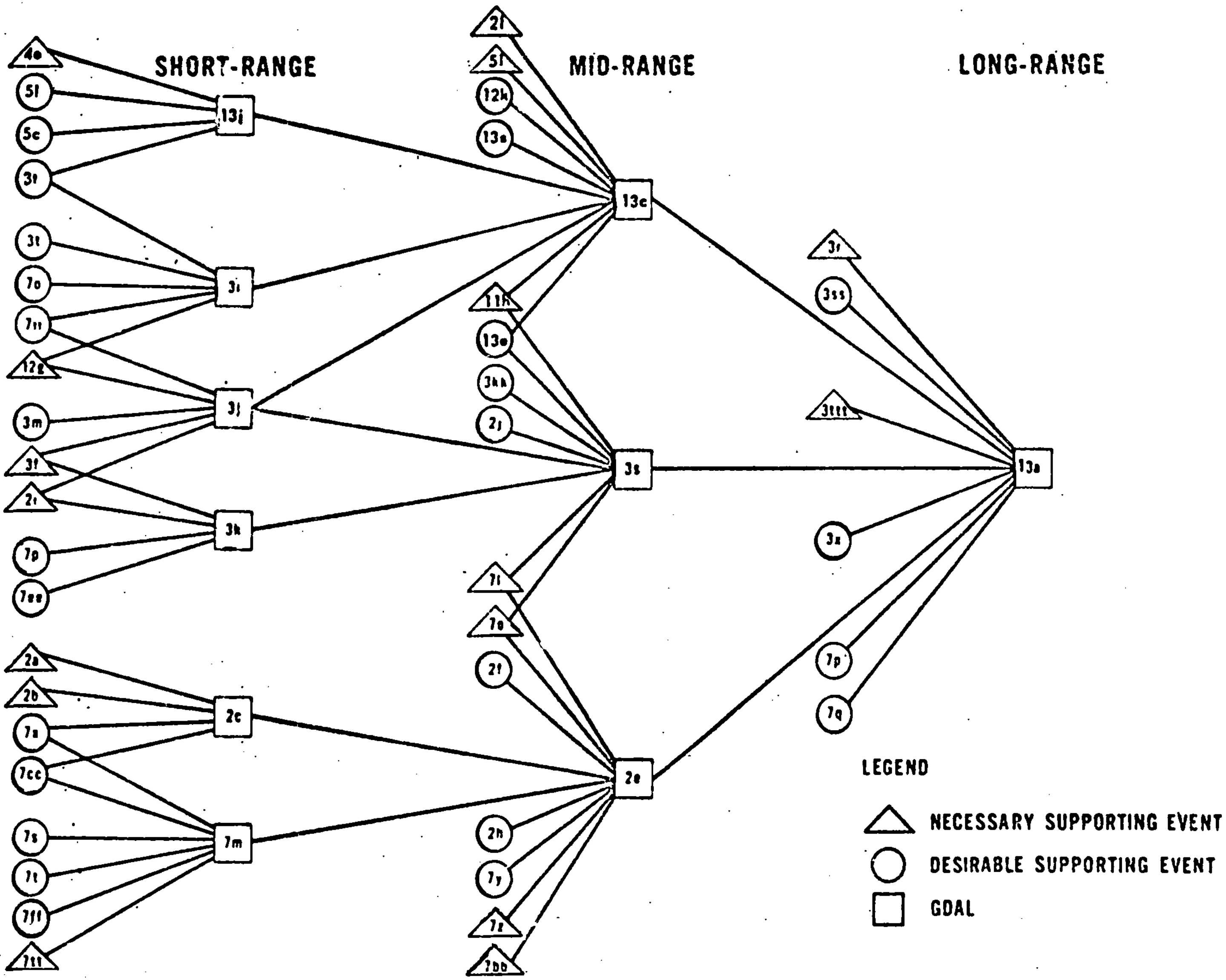
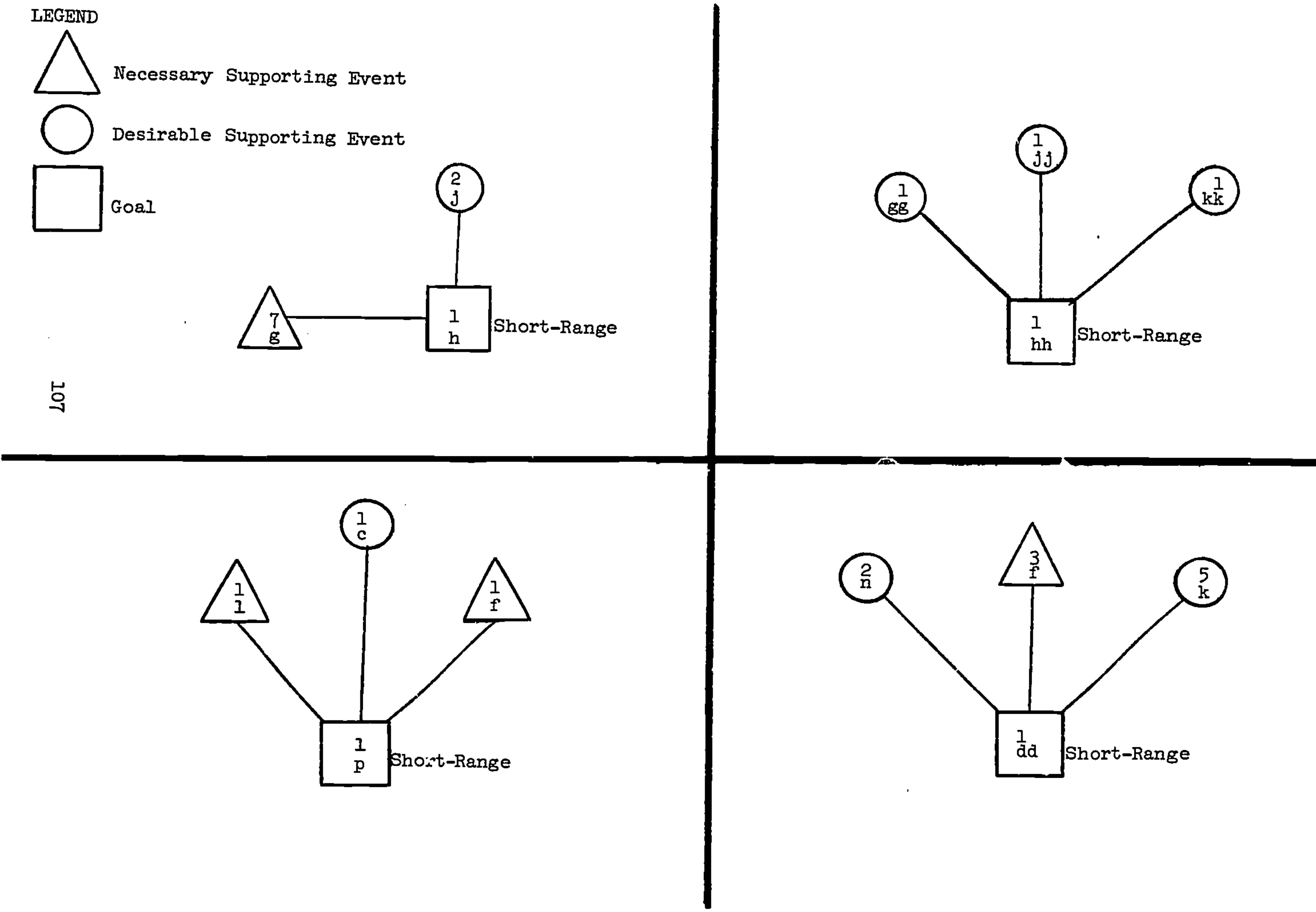
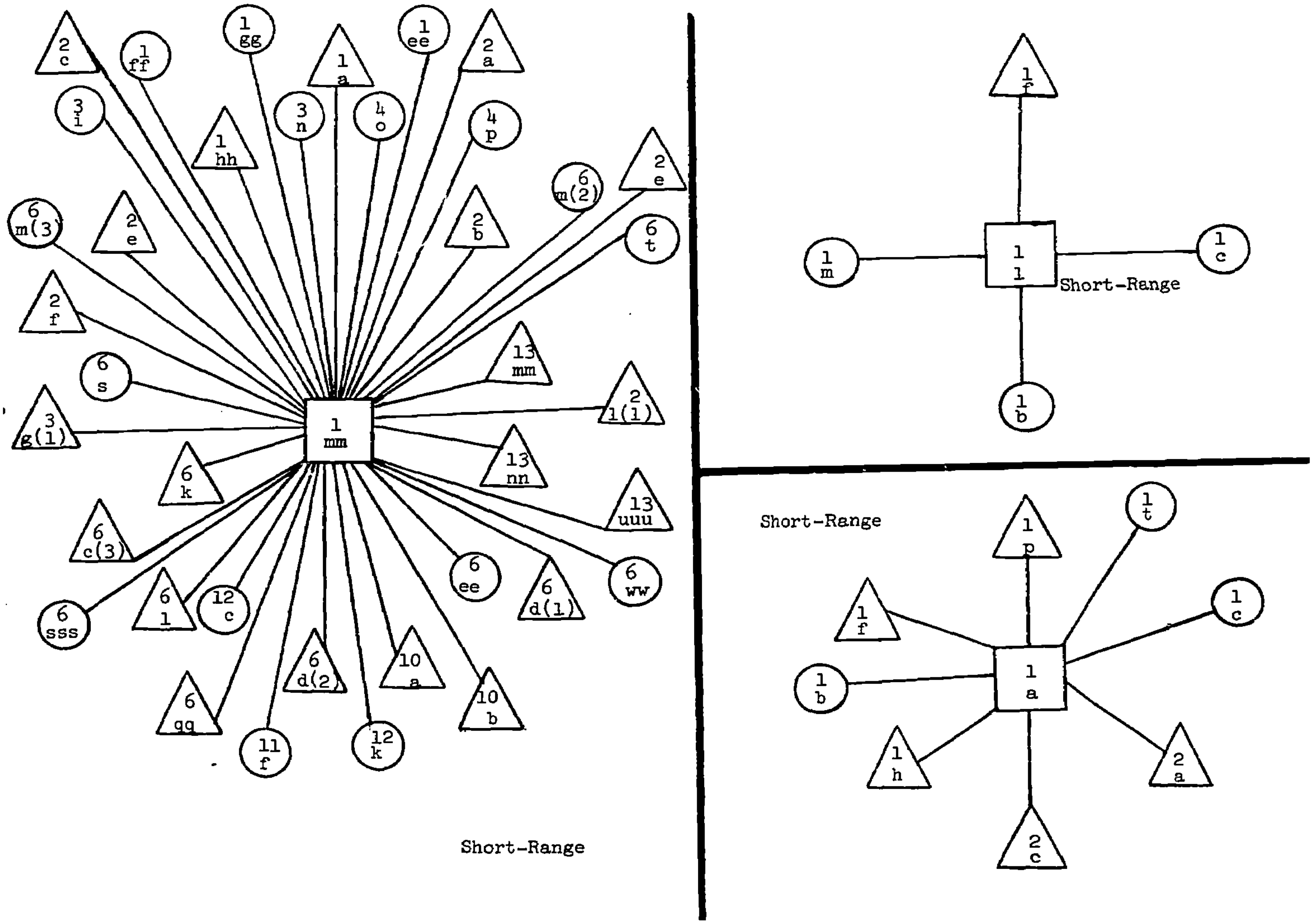


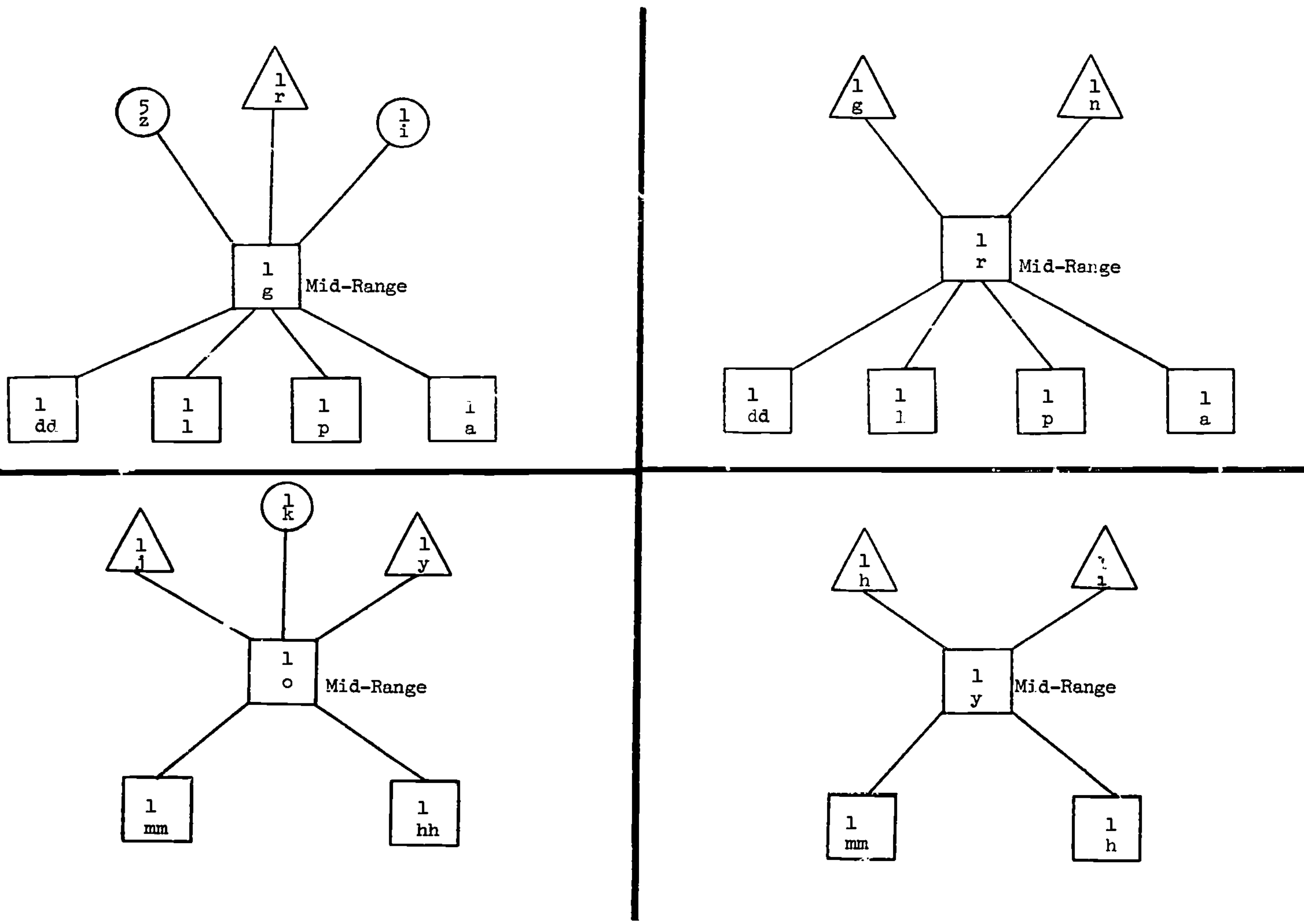
EXHIBIT 1 - AN ILLUSTRATION OF HOW THE MODELS MIGHT BE USED

Category/Item Identifier	Event
13/a	An international technical data system will be in operation with access by individual scientist through desk top devices.
13/c	Development of machine-processable languages capable of representing and simulating the combined action of hardware and software systems at whatever level is desired, from logic elements through modules and more complex units.
2/1	The one-hundred-fold increase in the use of large scale integrated circuit technology on a truly integrated basis.
11/h	Research identifying technical and cultural linguistic communities within a natural language, with a view to simplifying man-machine intercommunication by specifying the linguistic environment.
5/1	An inexpensive alphanumeric terminal (with limited graphic capability) will revolutionize this field at about $1K per terminal.
12/k	User will have his choice of performing many functions either in the hardware or as programmed in the software.
13/s	Hardware and software purchases will be divorced.
13/e	With the advent of time-sharing, interpreters will assume greater importance in systems, and provide simpler processing of variability.
13/j	A major increase in the use of computers for simulation is predicted facilitated by major changes in the use of peripheral equipment.
4/e	I/O data communication terminals will become more versatile at higher speeds and lower costs by sharing common control electronics within geographical clusters.
3/t	Very cheap special purpose computers to solve specific data processing problems in standardized ways will be available.
5/c	A flat TV tube providing reduced glare will be available on the market at reduced cost.



LEGEND
Necessary Supporting Event
Desirable Supporting Event
Goal
2 j
7 g
1 h
Short-Range
1 jj
1 gg
1 kk
1 hh
Short-Range
1 c
1 l
1 f
1 p
Short-Range
2 n
3 f
5 k
1 dd
Short-Range


1 mm
2 c
1 ff
1 gg
1 a
1 ee
2 a
3 i
1 hh
3 n
4 o
4 p
6 m(2)
2 e
6 m(3)
2 e
2 b
6 t
2 f
13 mm
6 s
2 l(1)
3 g(1)
6 k
13 nn
13 uuu
6 c(3)
6 ee
6 d(1)
6 ww
6 sss
6 l
12 c
6 d(2)
10 a
10 b
6 gg
11 f
12 k
Short-Range
1 l
1 f
1 m
1 c
1 b
Short-Range
1 a
1 p
1 t
1 f
1 c
1 b
1 h
2 a
2 c
Short-Range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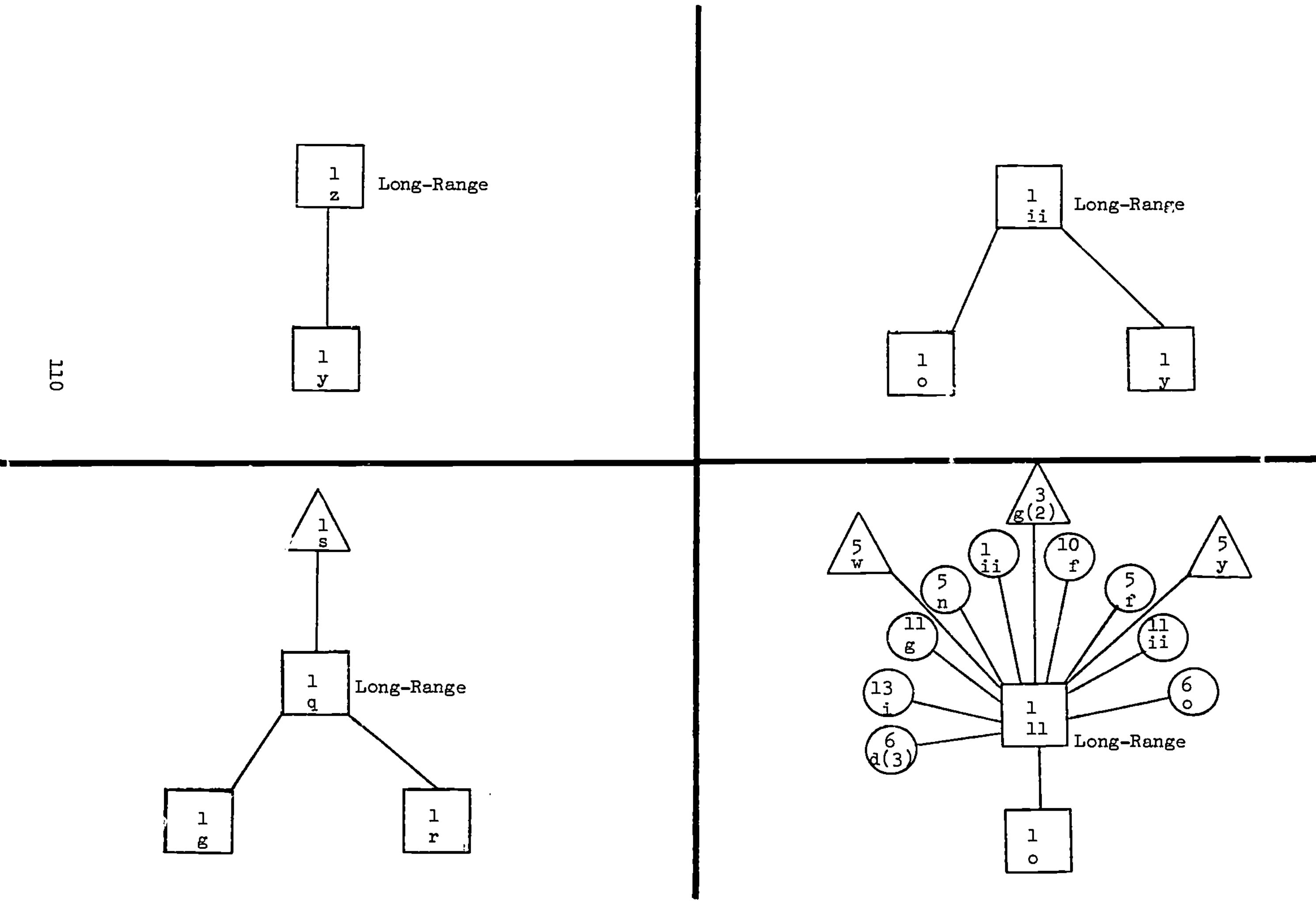
1 r
1 i
1 g
Mid-Range
1 dd
1 l
1 p
1 a
1 g
1 n
1 r
Mid-Range
1 dd
1 l
1 p
1 a
1 j
1 k
1 y
1 o
Mid-Range
1 mm
1 hh
1 h
1 y
Mid-Range
1 mm
1 h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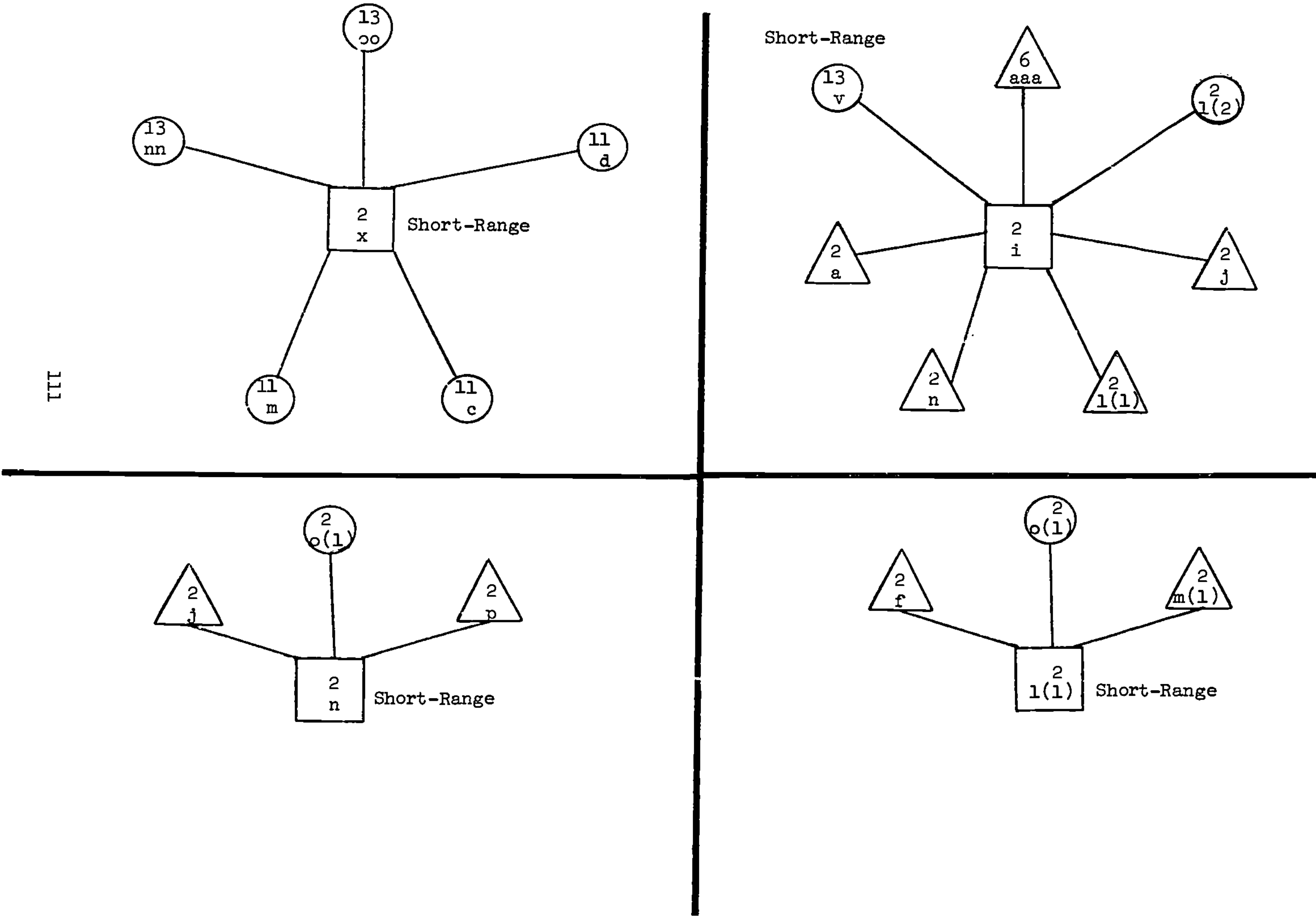
Long-Range
1 y
1 ii
Long-Range
1 o
1 y
1 s
1 q
Long-Range
1 g
1 r
3 g(2)
5 w
1 ii
10 f
5 y
5 n
5 f
11 g
11 ii
13 i
6 o
1 11
Long-Range
6 d(3)
1 o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oo
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nn
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d
2
x
Short-Range
11
m
11
c
Short-Range
13
v
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aaa
2
l(2)
2
a
2
i
2
j
2
n
2
l(1)
2
o(l)
2
j
2
p
2
n
Short-Range
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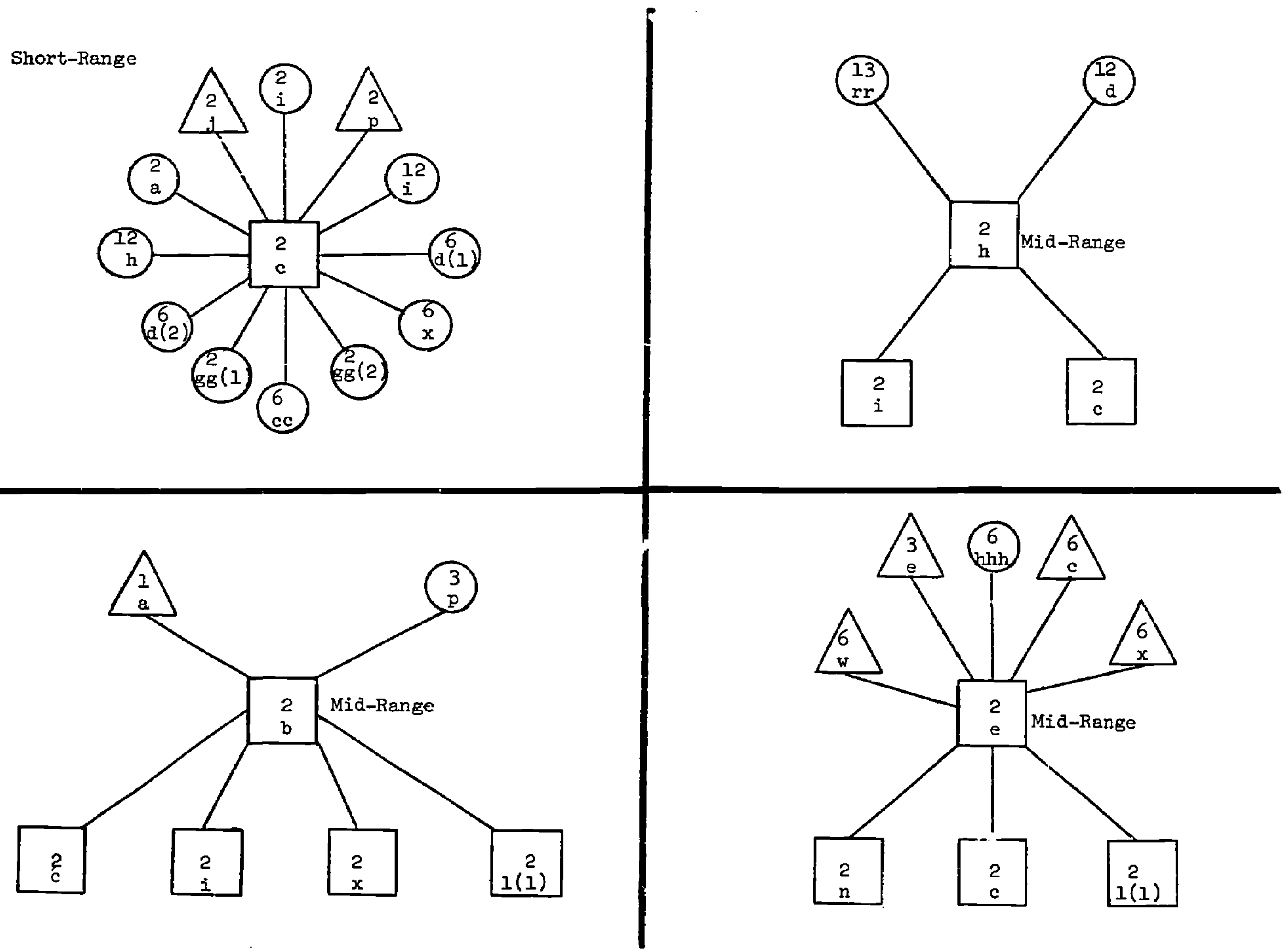
o(l)
2
f
2
m(l)
2
l(l)
Short-Range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2 j
2 i
2 p
2 a
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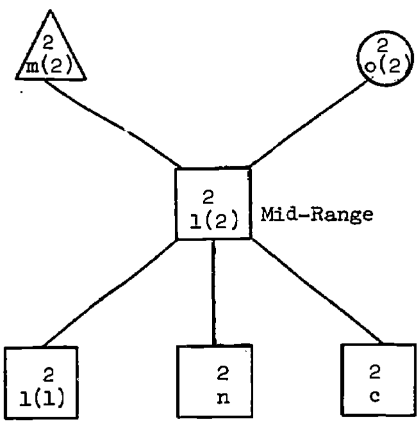
12 h
6 d(1)
6 d(2)
6 x
2 gg(1)
6 cc
2 gg(2)
13 rr
12 d
2 h
Mid-Range
2 i
2 c
1 a
3 p
2 b
Mid-Range
2 c
2 i
2 x
2 l(1)
3 e
6 hhh
6 c
6 w
6 x
2 e
Mid-Range
2 n
2 c
2 l(1)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o(2)
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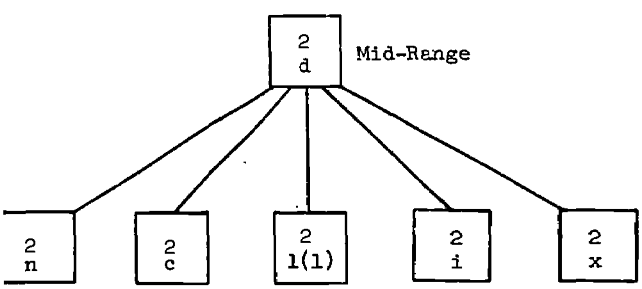
l(2)
Mid-Range
2
l(1)
2
n
2
c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d
Mid-Range
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c
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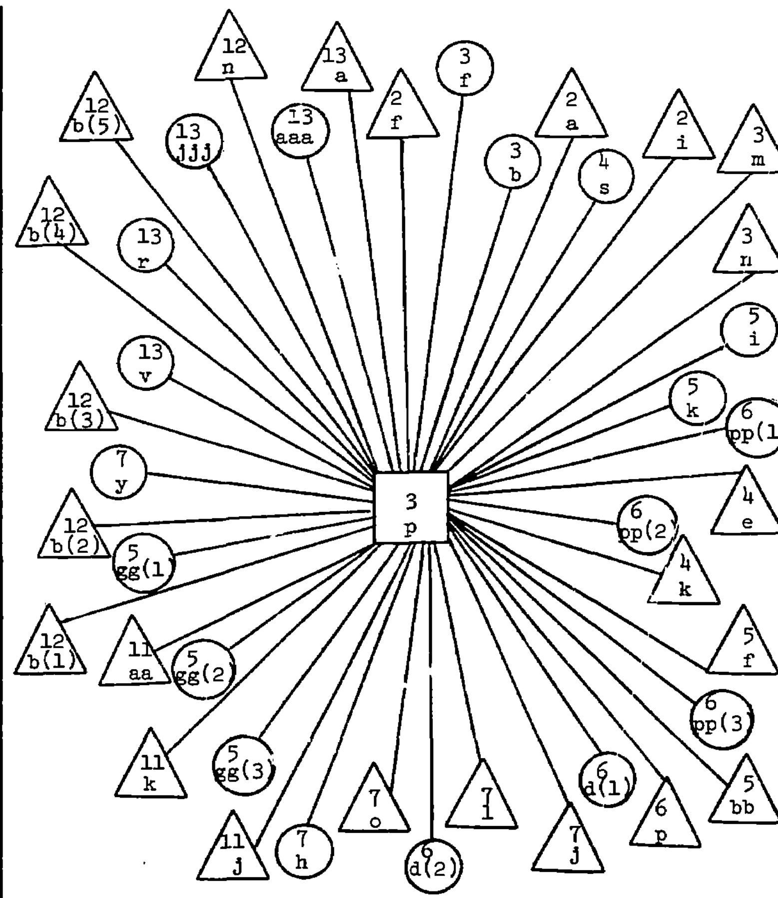
l(1)
2
i
2
x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f
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jjj
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aaa
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a
2
i
3
m
3
b
4
s
12
b(4)
13
r
3
n
5
i
13
v
12
b(3)
5
k
6
pp(1)
7
y
4
e
12
b(2)
5
gg(1)
6
pp(2)
4
k
12
b(1)
11
aa
5
gg(2)
5
f
6
pp(3)
11
k
5
gg(3)
6
d(1)
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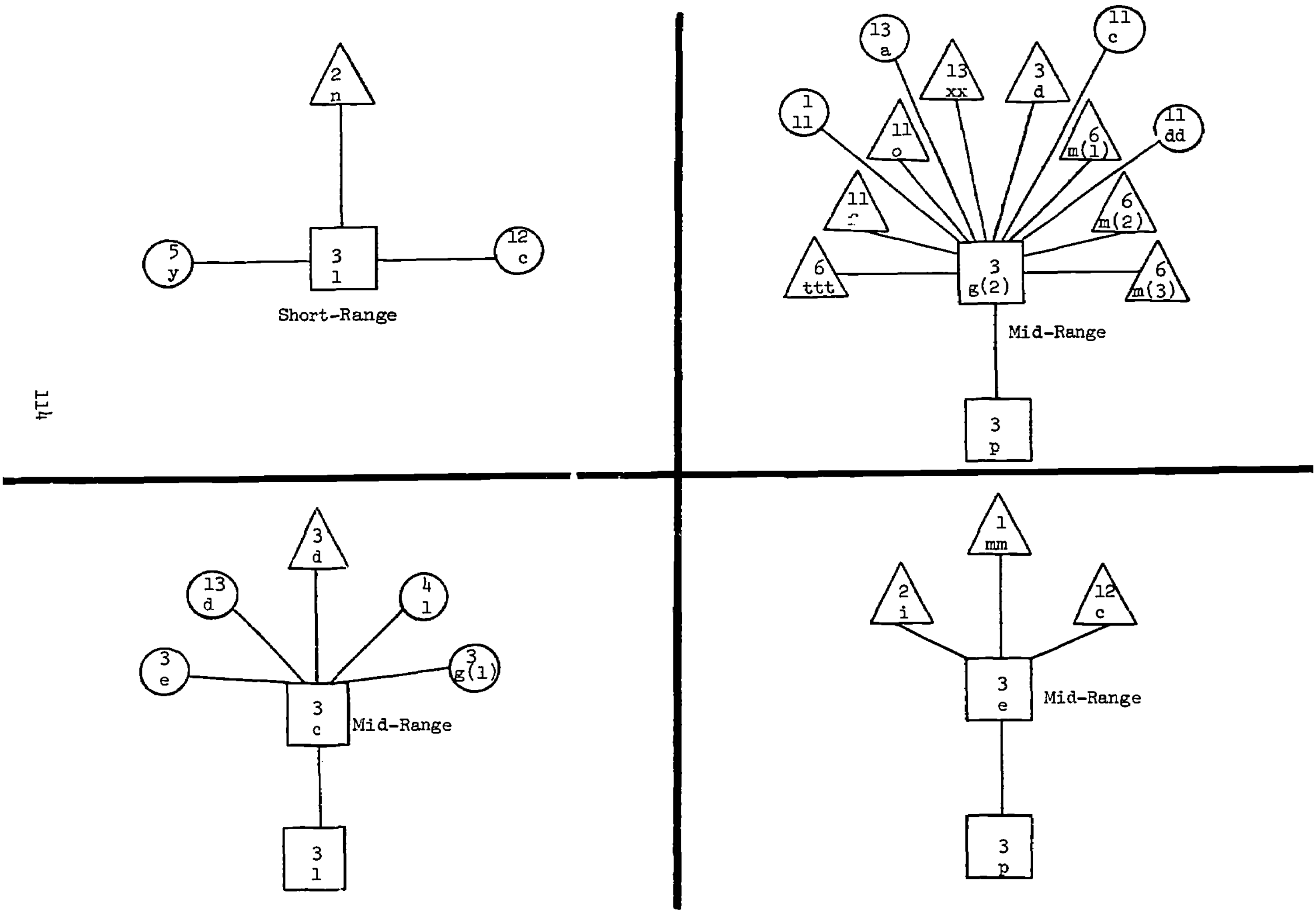
j
7
h
6
d(2)
7
j

Short-Range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3 l
12 c
Short-Range
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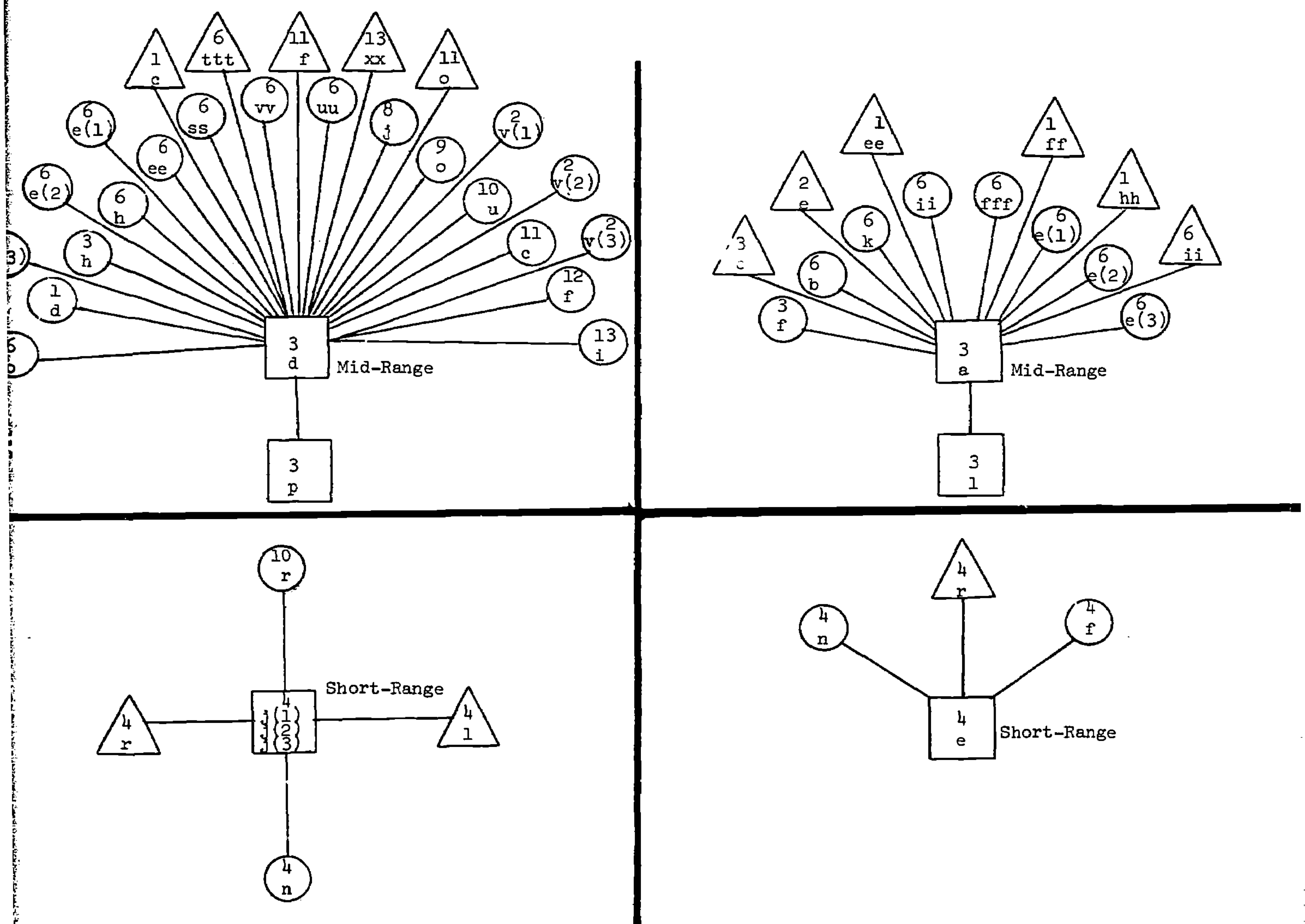
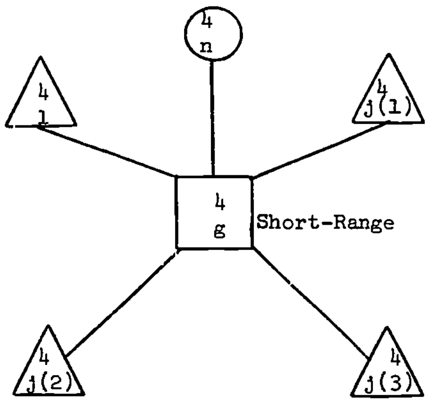
3 d
1 11
11 o
6 m(1)
11 dd
11 f
6 m(2)
6 ttt
3 g(2)
6 m(3)
Mid-Range
3 p
3 d
13 d
4 l
3 e
3 g(1)
3 c
Mid-Range
3 l
1 mm
2 i
12 c
3 e
Mid-Range
3 p



1 c
6 ttt
11 f
13 xx
11 o
6 e(1)
6 ss
6 vv
6 uu
8 j
2 v(1)
6 ee
9 o
6 e(2)
6 h
10 u
2 v(2)
3 h
11 c
2 v(3)
1 d
12 f
13 i
3 d
Mid-Range
3 p
1 ee
1 ff
2 e
6 ii
6 fff
1 hh
6 k
6 e(1)
6 ii
3 c
6 b
6 e(2)
3 f
6 e(3)
3 a
Mid-Range
3 l
10 r
Short-Range
4 r
4 (1) (2) (3)
4 l
4 n
4 r
4 n
4 f
4 e
Short-Range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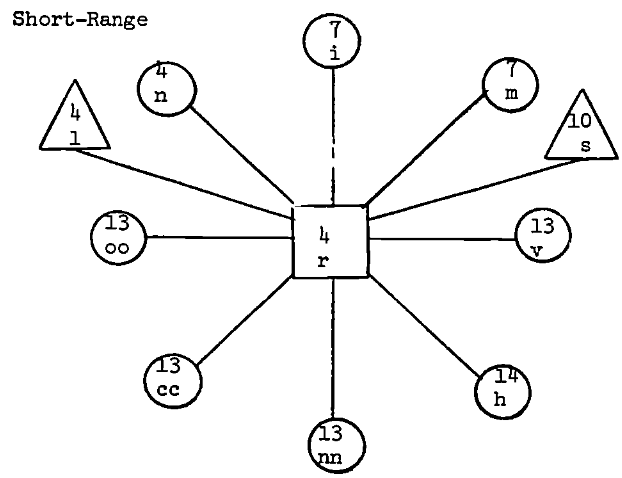
j(2)
4
j(3)


Short-Range
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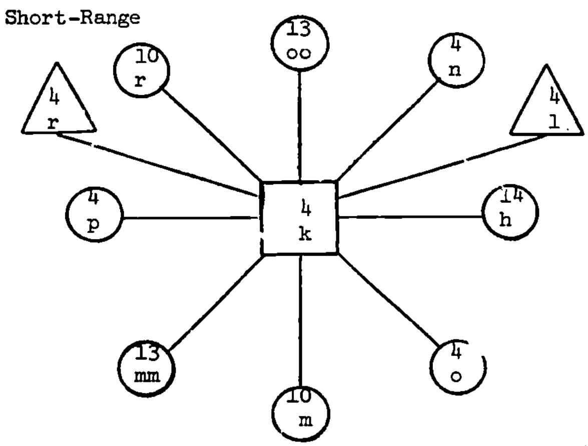
nn


Short-Range
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r
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r
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l
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p
4
k
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h
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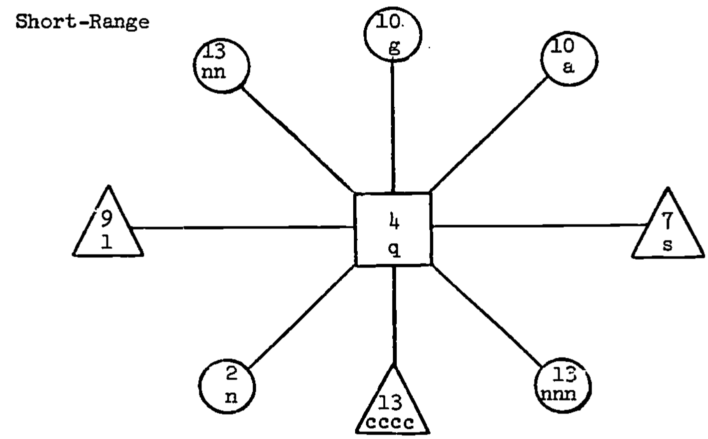
mm
4
o
10
m


Short-Range
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s
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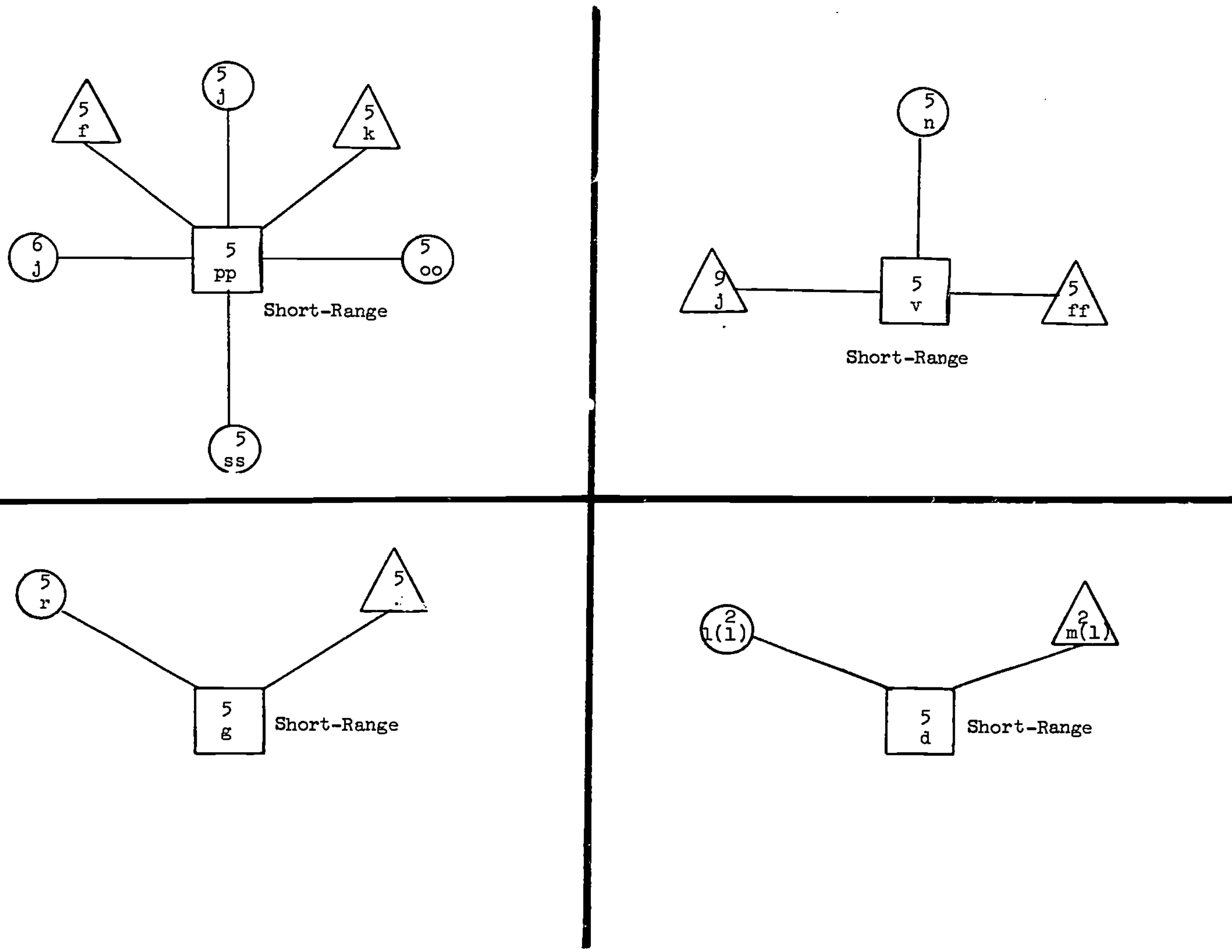
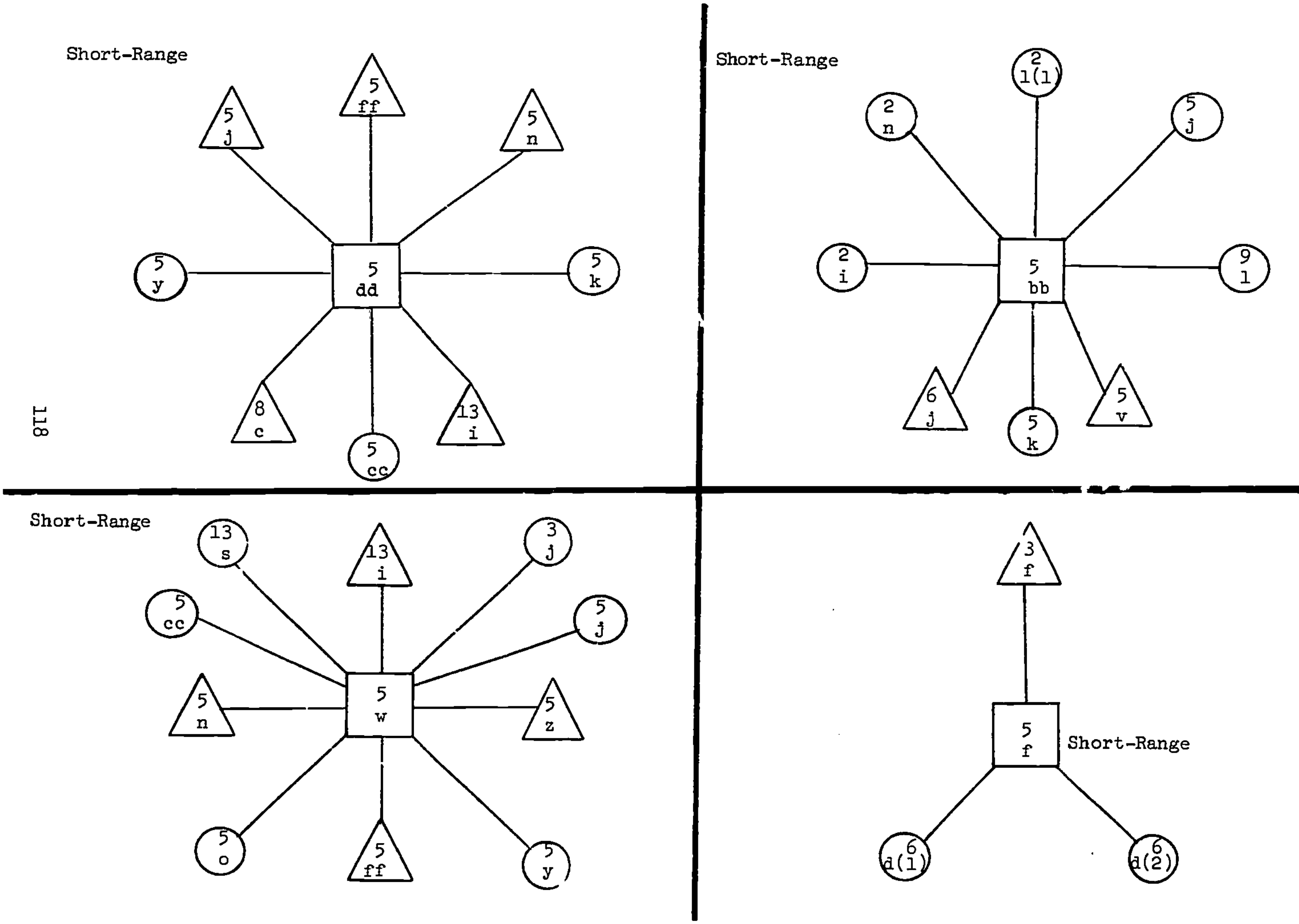


5 f
5 j
5 k
6 j
5 pp
5 oo
Short-Range
5 ss
5 n
9 j
5 v
5 ff
Short-Range
5 r
5
5 g
Short-Range
2 l(1)
2 m(1)
5 d
Short-Range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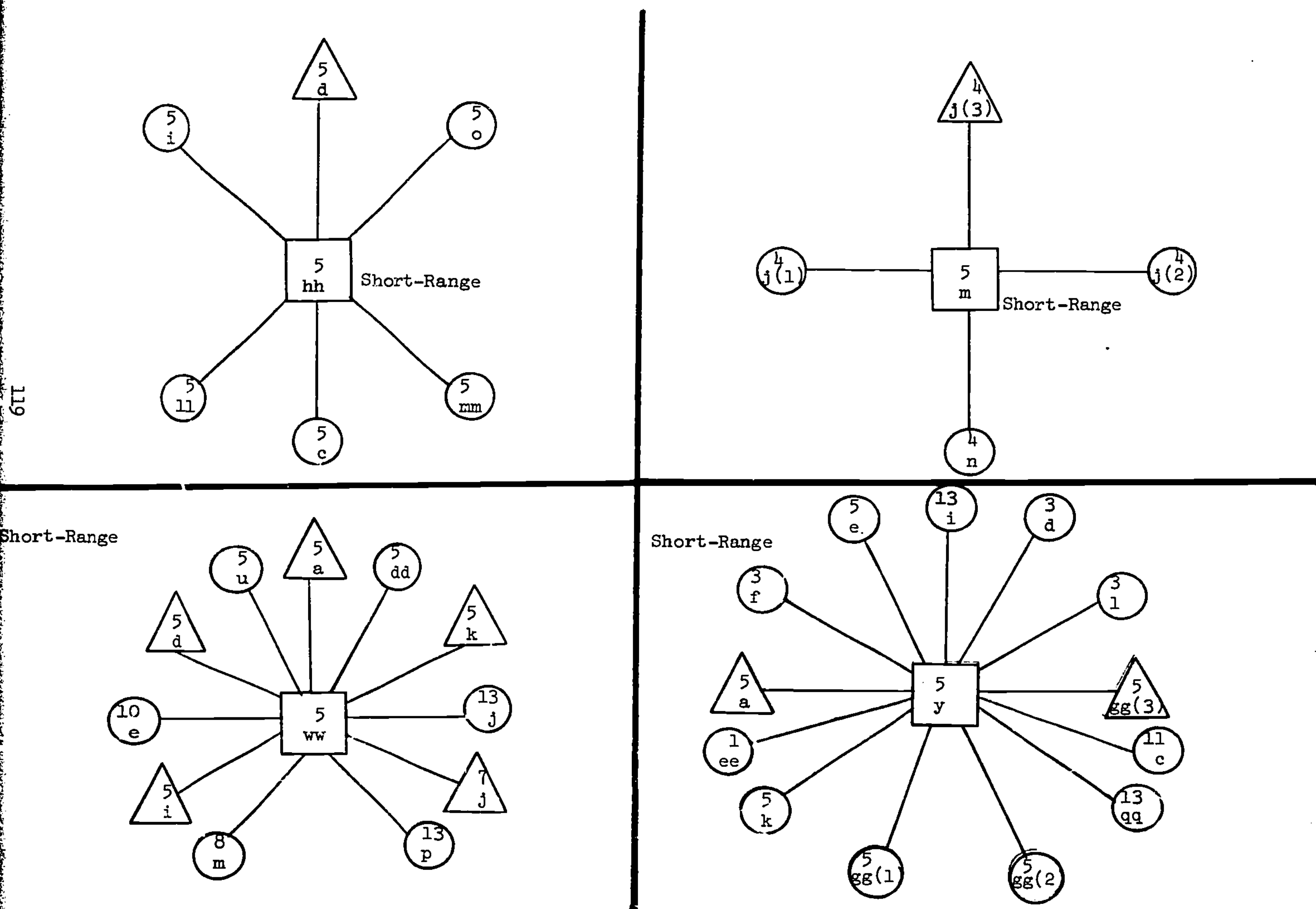
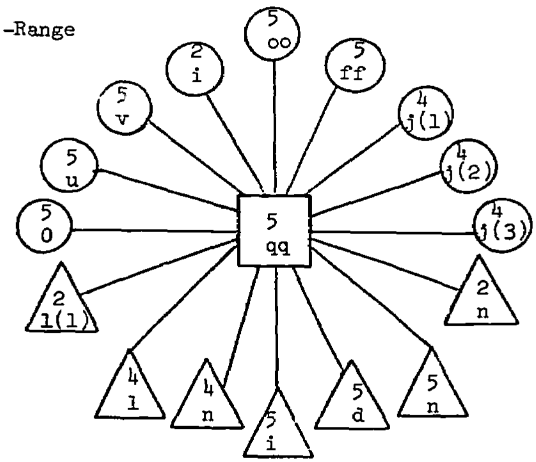
5 ff
5 n
5 y
5 dd
5 k
8 c
5 cc
13 i
Short-Range
2 n
2 1(1)
5 j
2 i
5 bb
9 1
6 j
5 k
5 v
Short-Range
13 s
13 i
3 j
5 cc
5 j
5 n
5 w
5 z
5 o
5 ff
5 y
3 f
5 f
Short-Range
6 d(1)
6 d(2)


5 d
5 i
5 o
5 hh
Short-Range
5 ll
5 c
5 mm
4 j(3)
4 j(1)
5 m
4 j(2)
Short-Range
4 n
Short-Range
5 u
5 a
5 dd
5 d
5 k
10 e
5 ww
13 j
5 i
7 j
8 m
13 p
Short-Range
5 e
13 i
3 d
3 f
3 l
5 a
5 y
5 gg(3)
1 ee
11 c
5 k
13 qq
5 gg(1)
5 gg(2)

Short-Range



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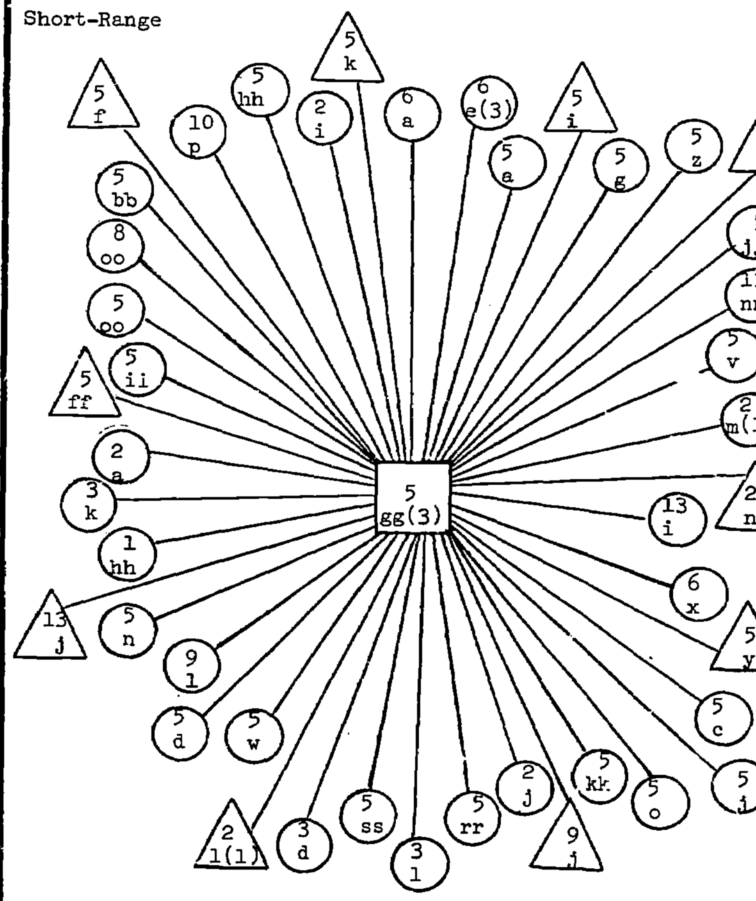

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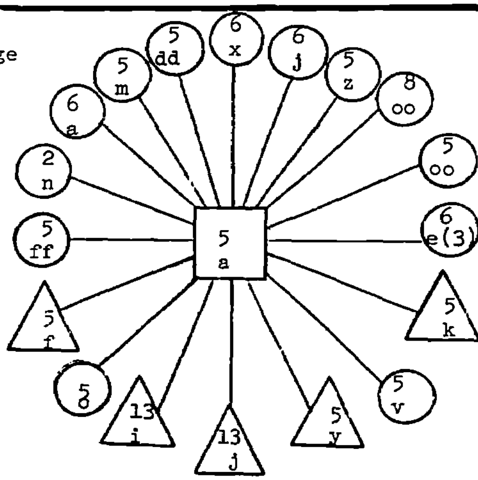
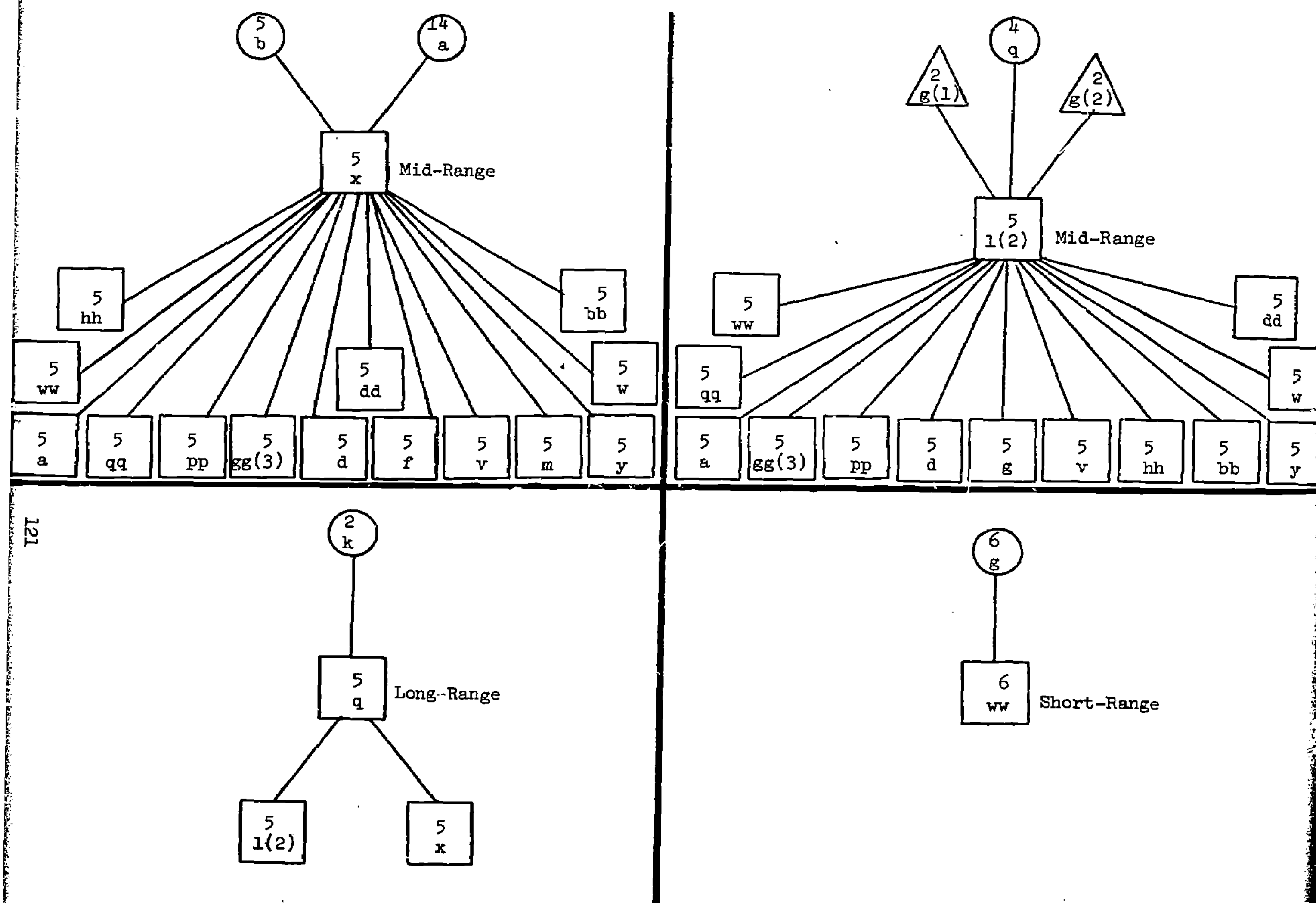
Short-Range




5 b
14 a
5 x
Mid-Range
5 hh
5 bb
5 ww
5 dd
5 w
5 a
5 qq
5 pp
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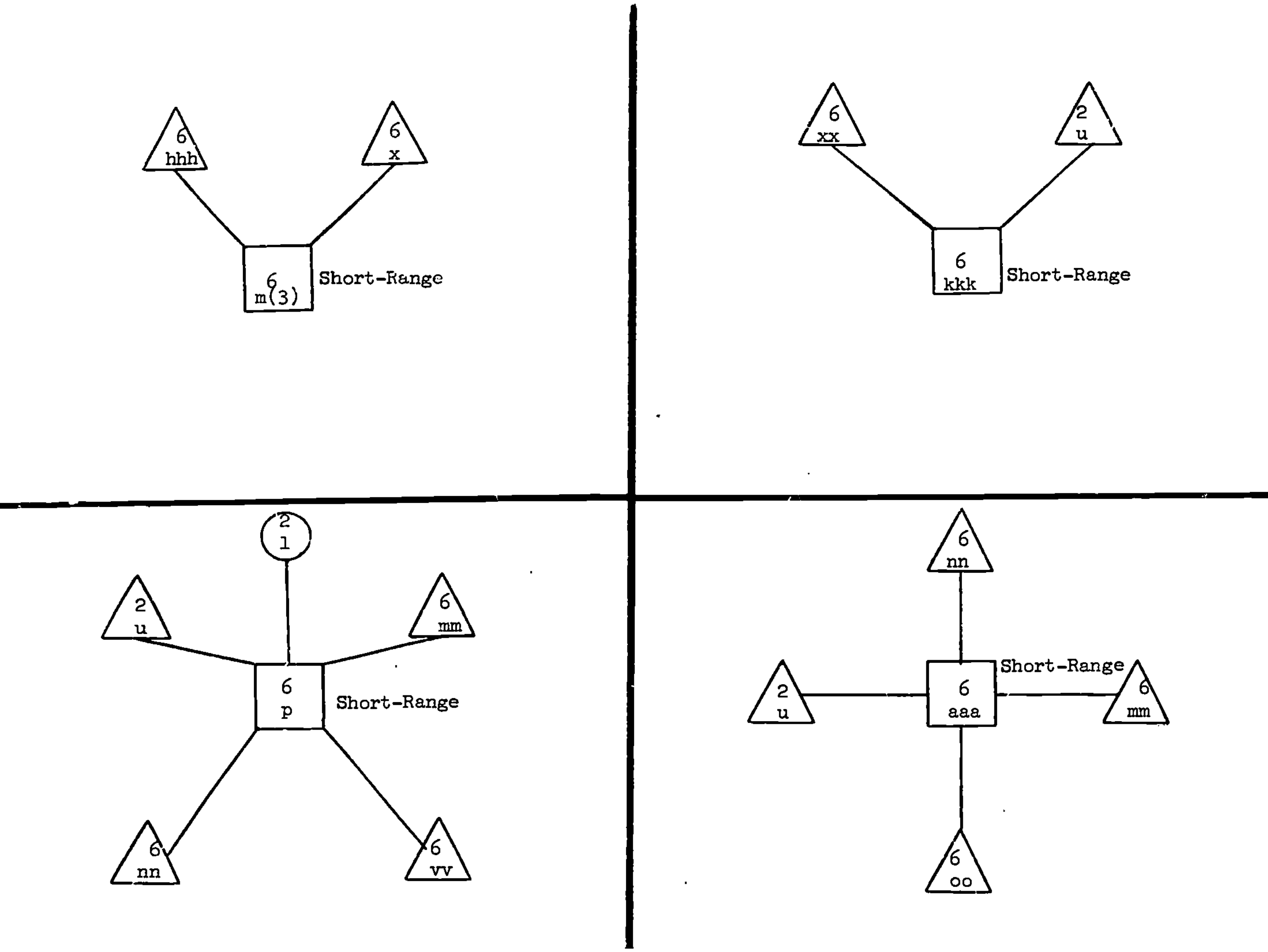
5 d
5 f
5 v
5 m
5 y
4 q
2 g(1)
2 g(2)
5 l(2)
Mid-Range
5 ww
5 dd
5 qq
5 w
5 a
5 gg(3)
5 pp
5 d
5 g
5 v
5 hh
5 bb
5 y
2 k
5 q
Long-Range
5 l(2)
5 x
6 g
6 ww
Short-Range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x
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m(3)
Short-Range
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xx
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u
6
kkk
Short-Range
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l
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u
6
mm
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nn
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vv
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Short-Range
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u
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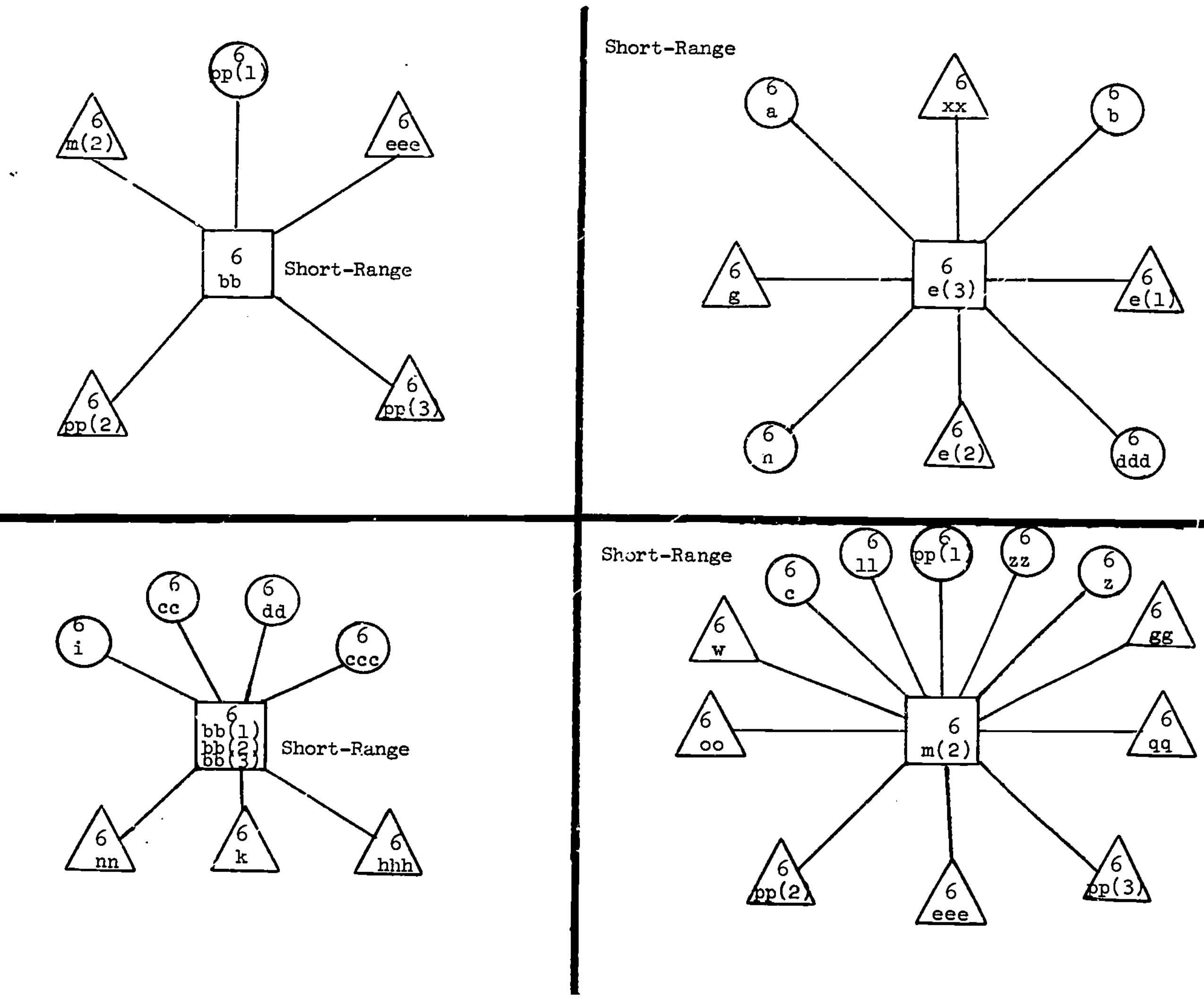
mm
6
oo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6 bb
Short-Range
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6 pp(3)
Short-Range
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6 b
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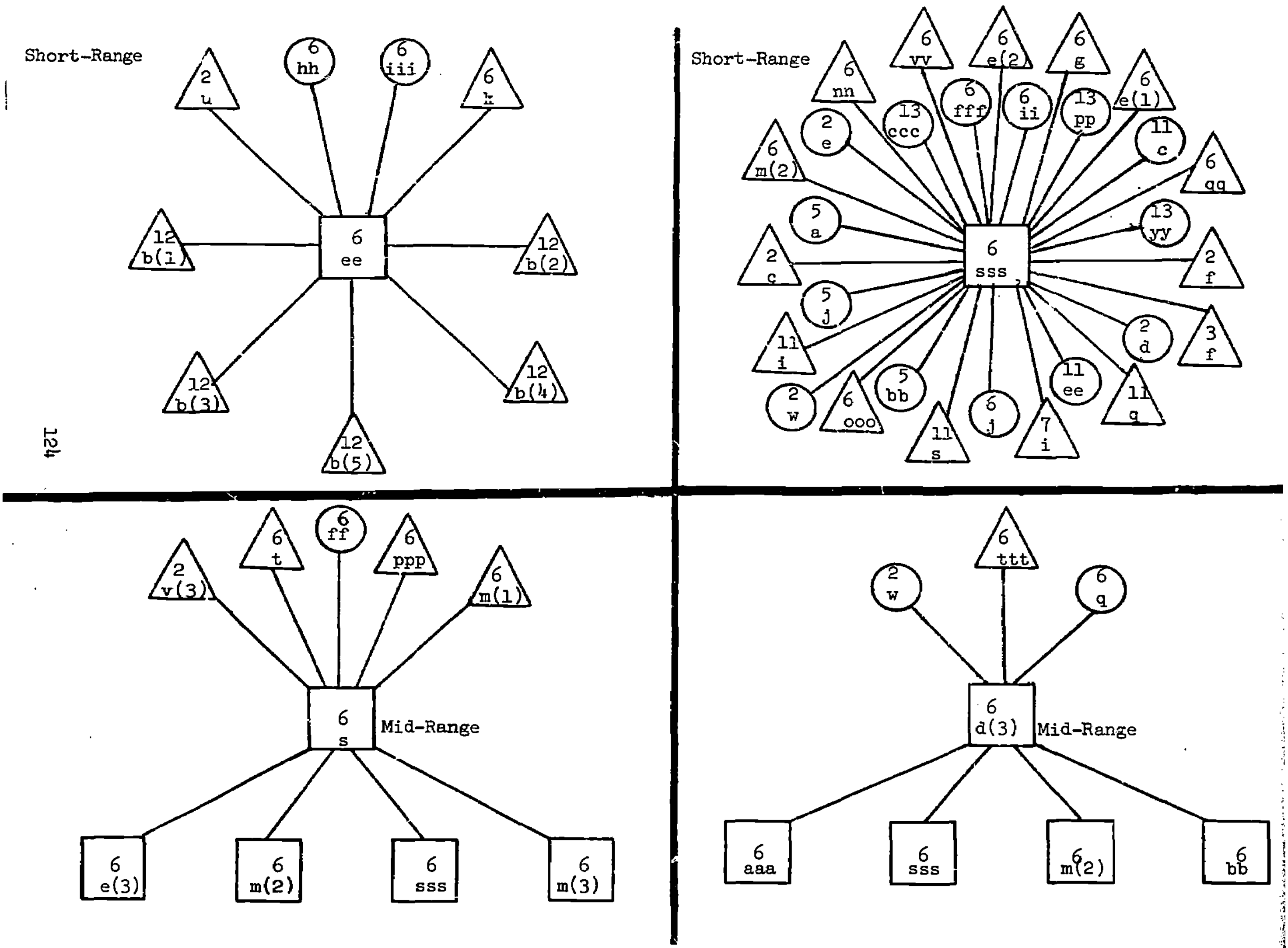
6 e(3)
6 e(1)
6 n
6 e(2)
6 ddd
6 cc
6 dd
6 i
6 ccc
6 bb(1) bb(2) bb(3)
Short-Range
6 nn
6 k
6 hhh
Short-Range
6 ll
6 pp(1)
6 zz
6 c
6 z
6 w
6 gg
6 oo
6 m(2)
6 qq
6 pp(2)
6 eee
6 pp(3)



Short-Range
2 u
6 hh
6 iii
6 k
12 b(1)
6 ee
12 b(2)
12 b(3)
12 b(5)
12 b(4)
Short-Range
6 nn
6 vv
6 e(2)
6 g
6 e(1)
13 ccc
6 fff
6 ii
13 pp
2 e
11 c
6 m(2)
6 qq
5 a
13 yy
2 c
6 sss
2 f
5 j
3 f
11 i
2 d
2 w
6 ooo
5 bb
11 s
6 j
7 i
11 ee
11 q
2 v(3)
6 t
6 ff
6 ppp
6 m(1)
6 s
Mid-Range
6 e(3)
6 m(2)
6 sss
6 m(3)
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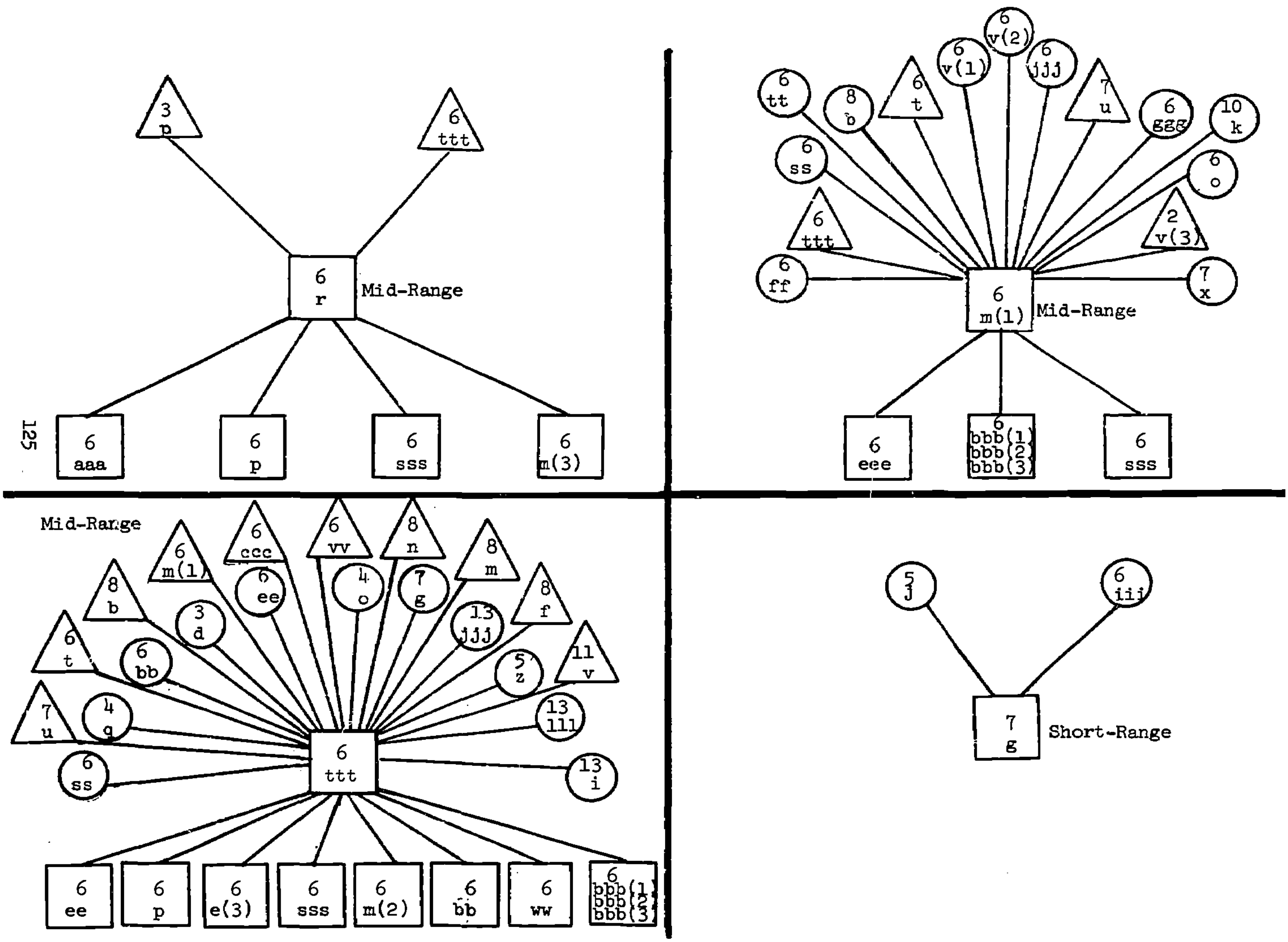
6 d(3)
Mid-Range
6 aaa
6 sss
6 m(2)
6 bb

124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6 ttt
6 r
Mid-Range
6 aaa
6 p
6 sss
6 m(3)
6 v(2)
6 v(1)
6 jjj
6 tt
8 b
6 t
7 u
6 ggg
10 k
6 ss
6 o
6 ttt
2 v(3)
6 ff
7 x
6 m(1)
Mid-Range
6 eee
6 bbb(1) bbb(2) bbb(3)
6 sss
Mid-Range
6 ccc
6 vv
8 n
6 m(1)
8 m
6 ee
4 o
7 g
8 b
3 d
13 jjj
8 f
6 t
6 bb
5 z
11 v
7 u
4 q
13 lll
6 ss
6 ttt
13 i
6 ee
6 p
6 e(3)
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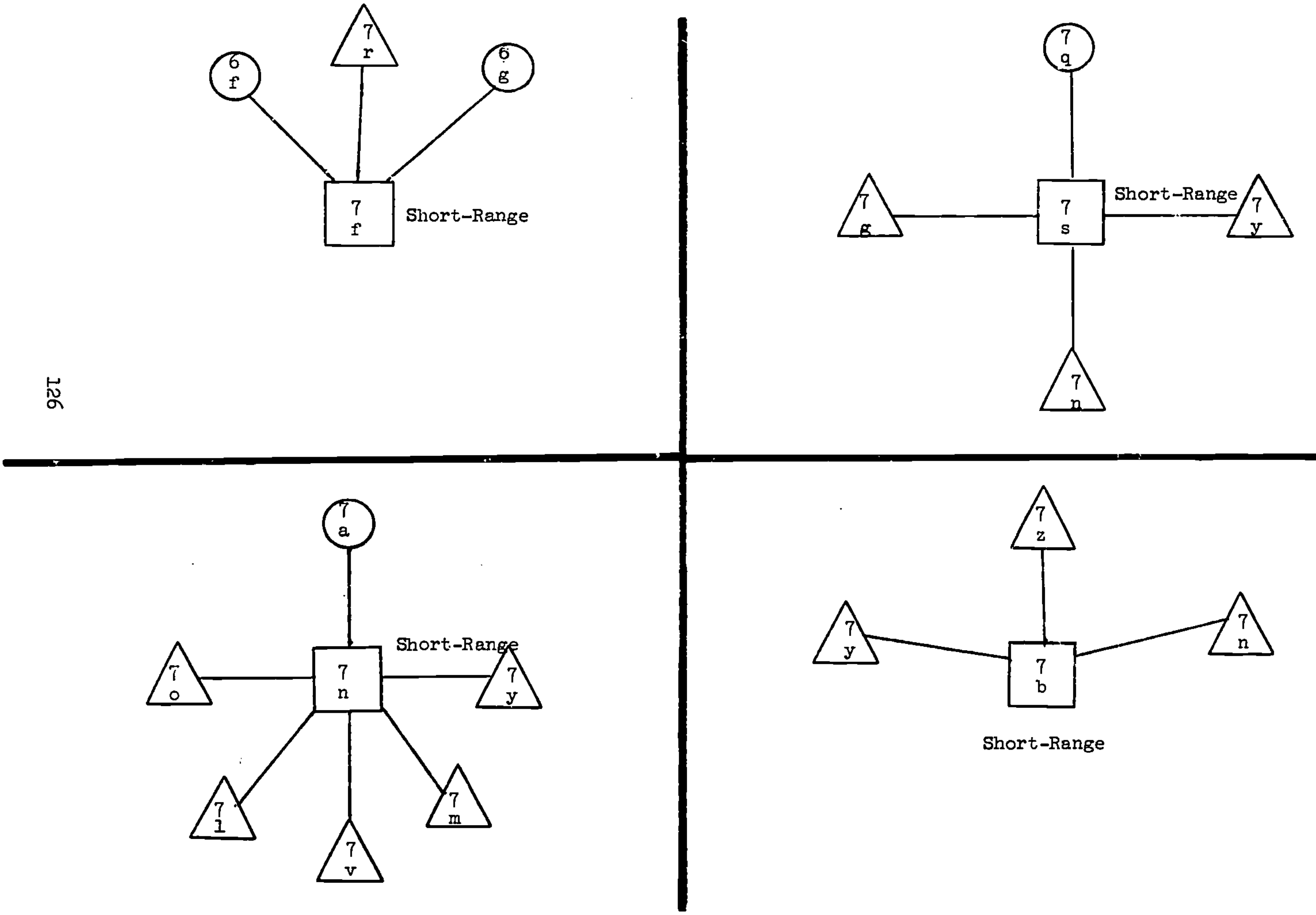
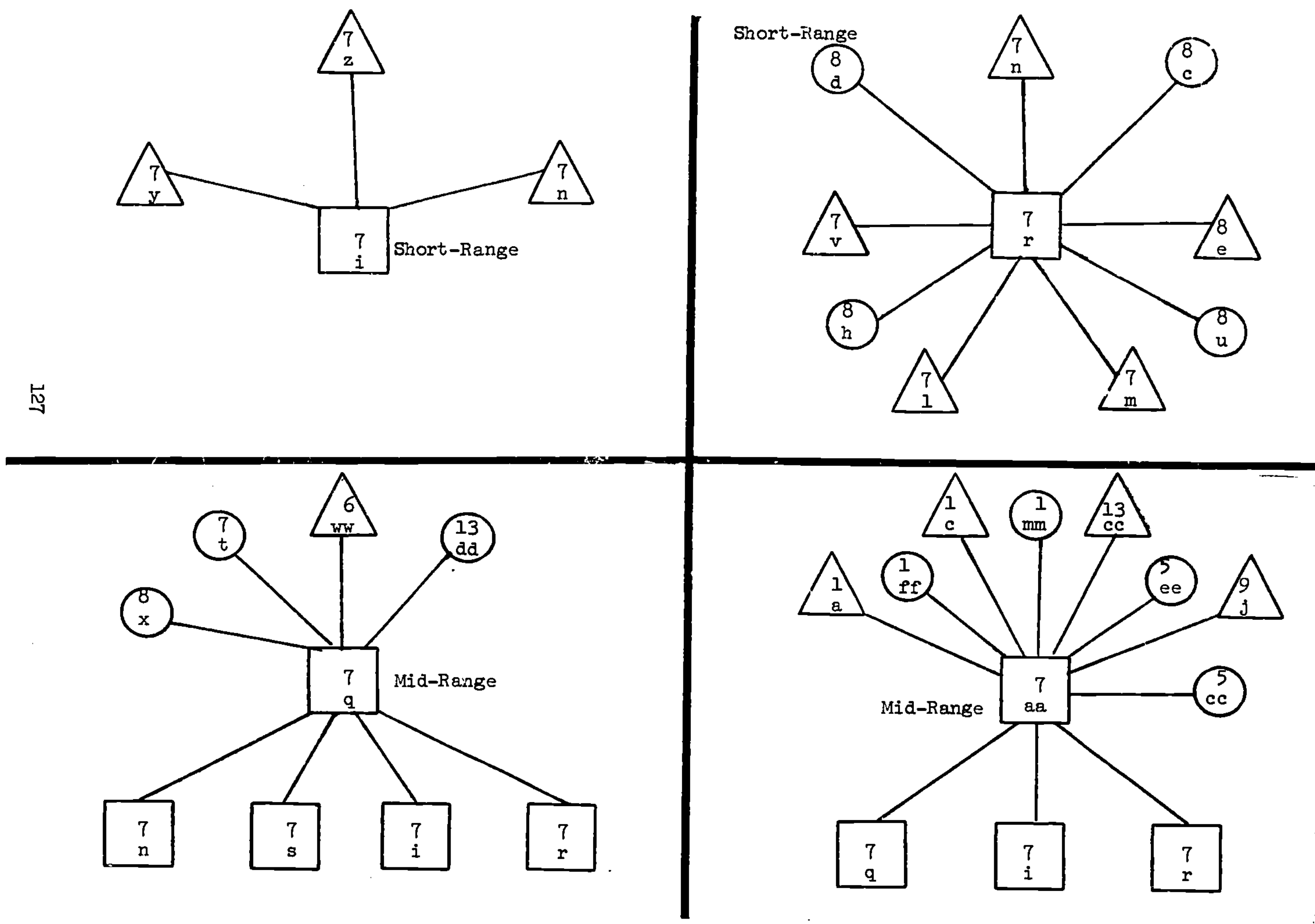
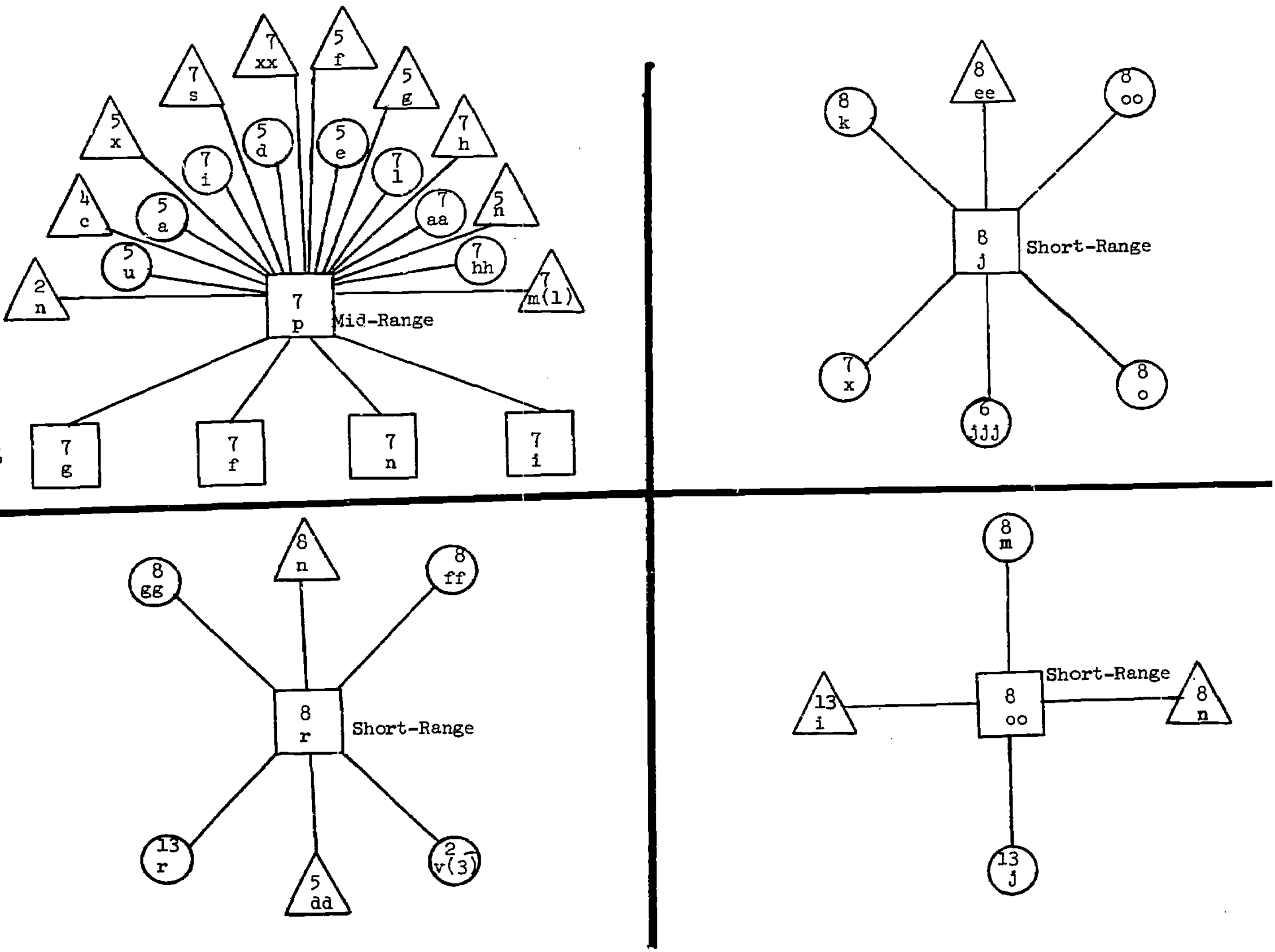
6 m(2)
6 bb
6 ww
6 bbb(1) bbb(2) bbb(3)
5 j
6 iii
7 g
Short-Range


6 f
7 r
6 g
7 f
Short-Range
7 q
7 g
7 s
Short-Range
7 y
7 n
7 a
7 o
7 n
Short-Range
7 y
7 l
7 v
7 m
7 z
7 y
7 b
7 n
Short-Range



7 z
7 y
7 n
7 i
Short-Range
Short-Range
8 d
7 n
8 c
7 v
7 r
8 e
8 h
8 u
7 l
7 m
7 t
6 ww
13 dd
8 x
7 q
Mid-Range
7 n
7 s
7 i
7 r
1 c
1 mm
13 cc
1 a
1 ff
5 ee
9 j
7 aa
Mid-Range
5 cc
7 q
7 i
7 r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7 s
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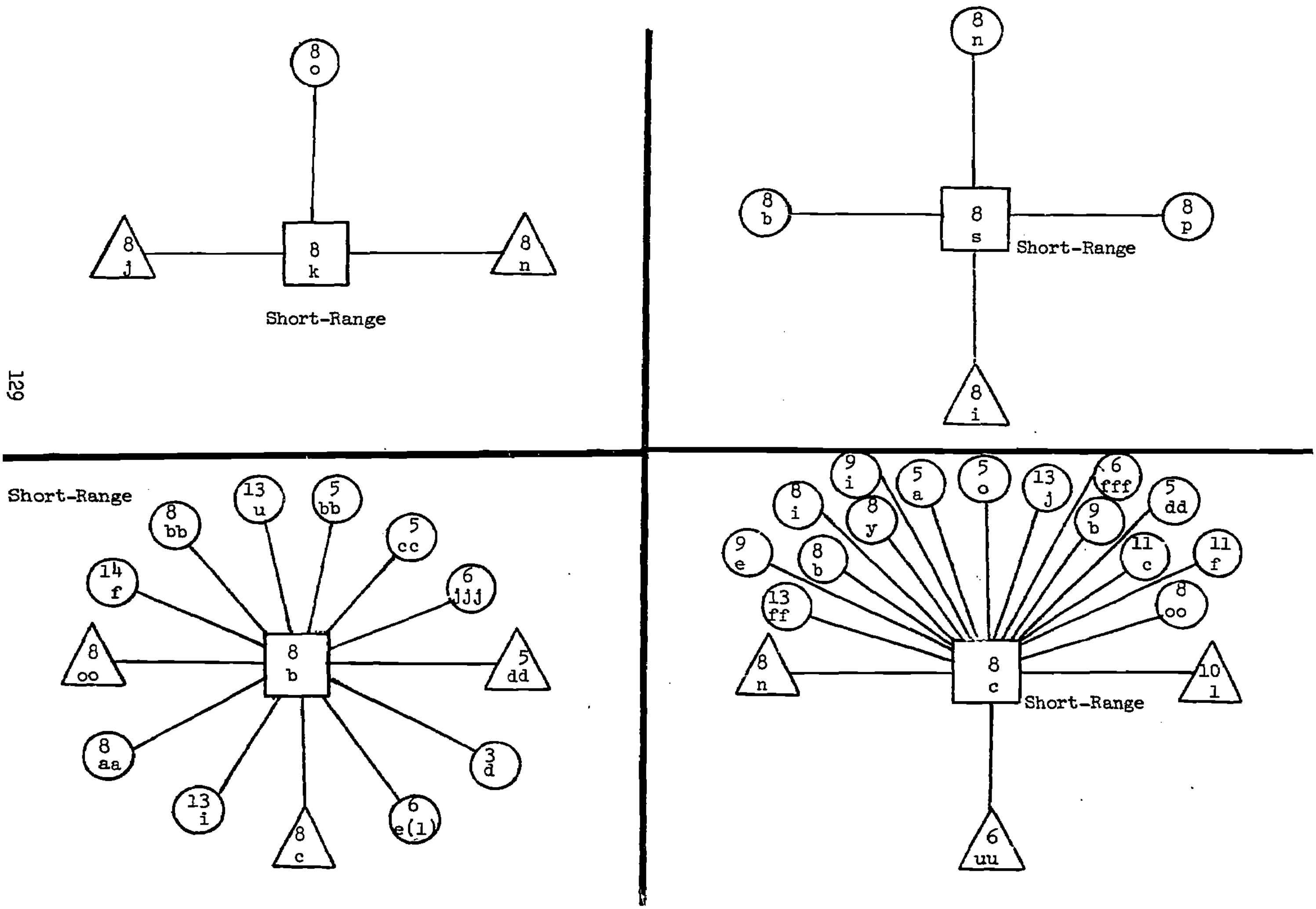
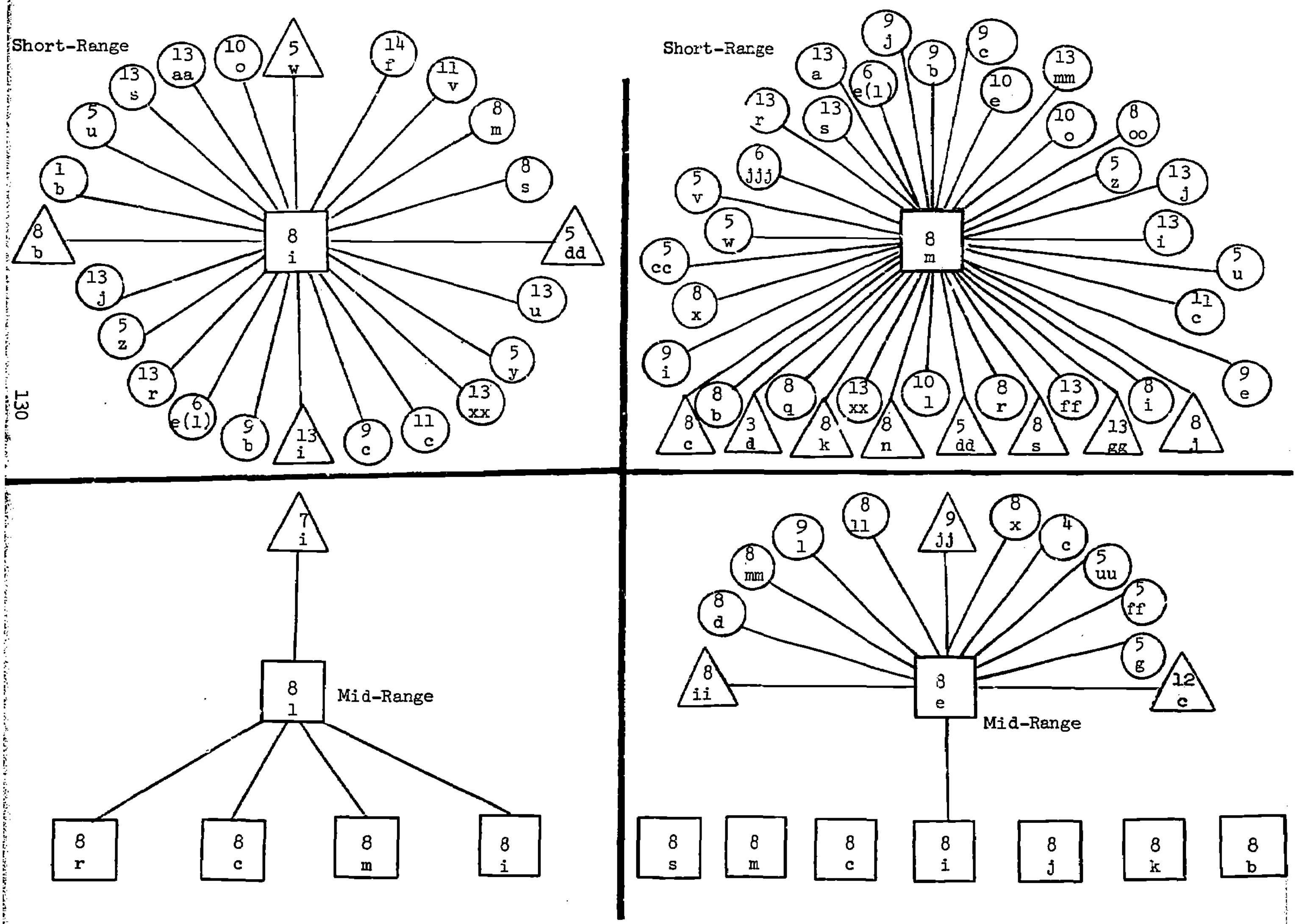
5 x
5 d
5 e
7 h
7 i
7 l
4 c
5 a
7 aa
5 n
5 u
7 hh
2 n
7 m(1)
7 p
Mid-Range
7 g
7 f
7 n
7 i
8 ee
8 k
8 oo
8 j
Short-Range
7 x
8 o
6 jjj
8 n
8 gg
8 ff
8 r
Short-Range
13 r
5 dd
2 v(3)
8 m
13 i
8 oo
Short-Range
8 n
13 j


8 o
8 j
8 k
8 n
Short-Range
8 n
8 b
8 s
8 p
Short-Range
8 i
Short-Range
13 u
5 bb
8 bb
5 cc
14 f
6 jjj
8 oo
8 b
5 dd
8 aa
3 d
13 i
6 e(1)
8 c
9 i
5 a
5 o
13 j
6 fff
8 i
8 y
9 b
5 dd
9 e
8 b
11 c
11 f
13 ff
8 oo
8 n
8 c
10 l
Short-Range
6 uu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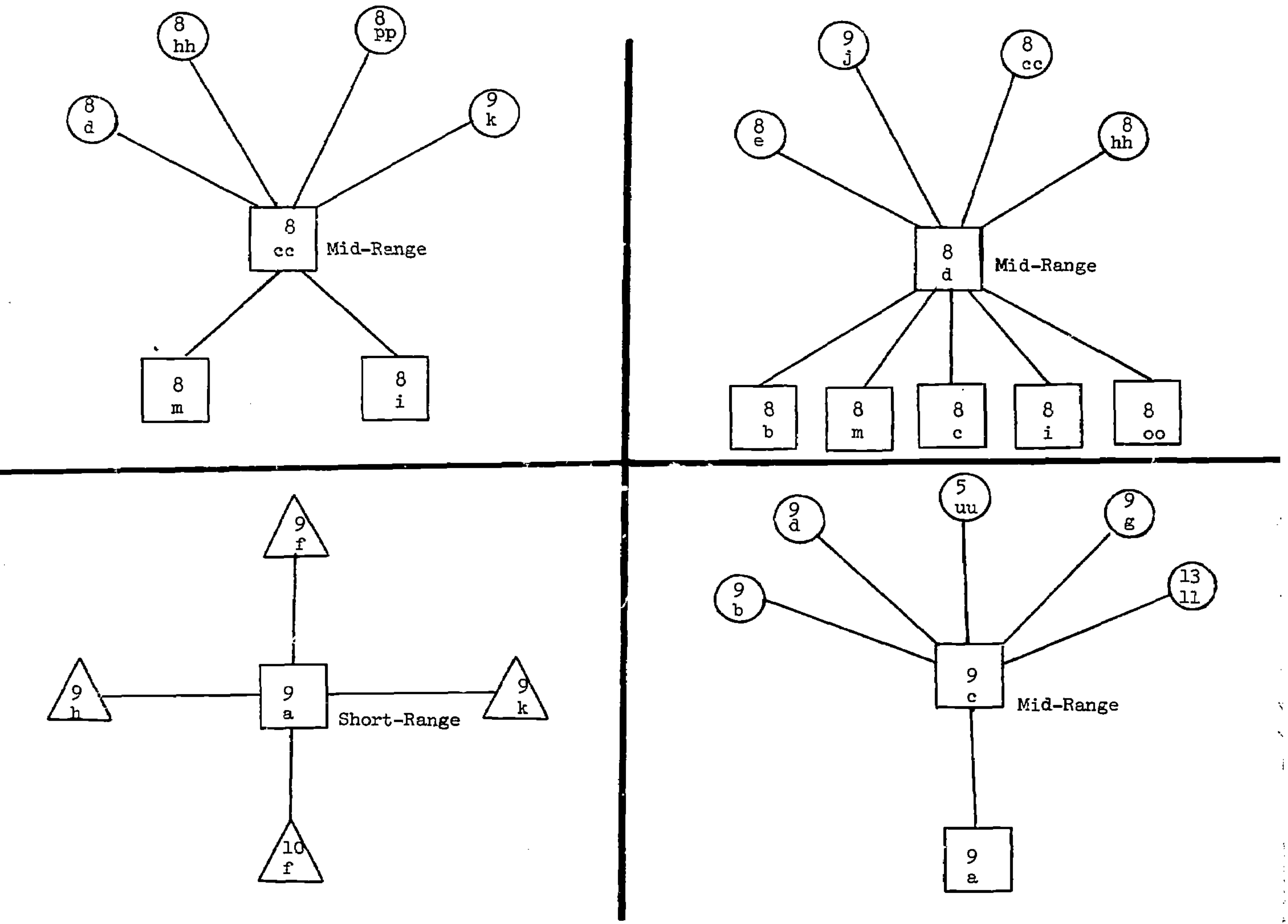
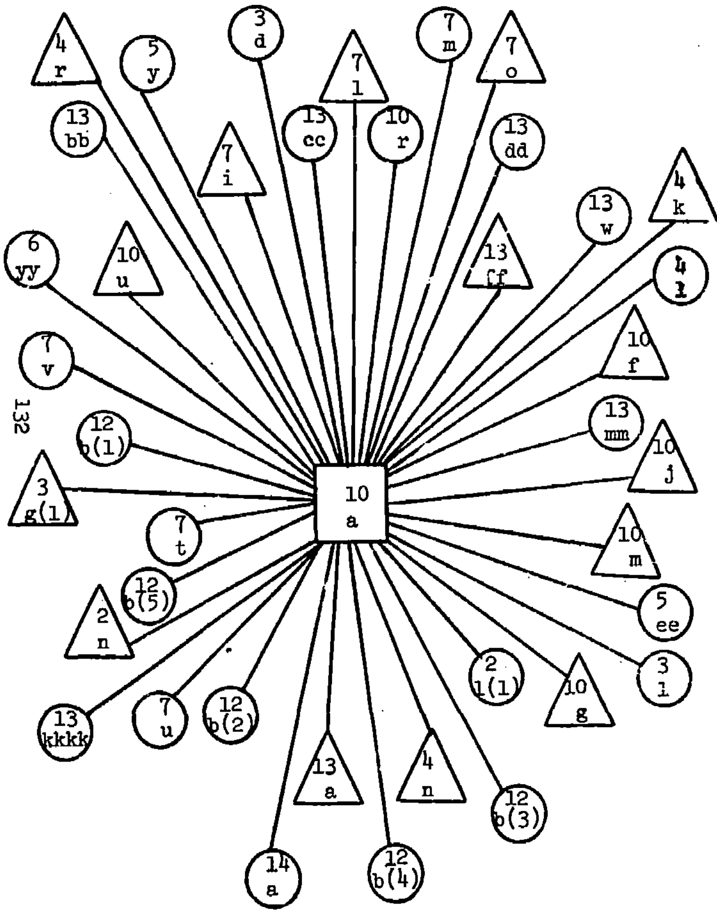
Short-Range
Mid-Range
Mid-Range


8 d
8 hh
8 pp
9 k
8 cc
Mid-Range
8 m
8 i
8 e
9 j
8 cc
8 hh
8 d
Mid-Range
8 b
8 m
8 c
8 i
8 oo
9 f
9 h
9 a
Short-Range
9 k
10 f
9 d
5 uu
9 g
9 b
13 11
9 c
Mid-Range
9 a



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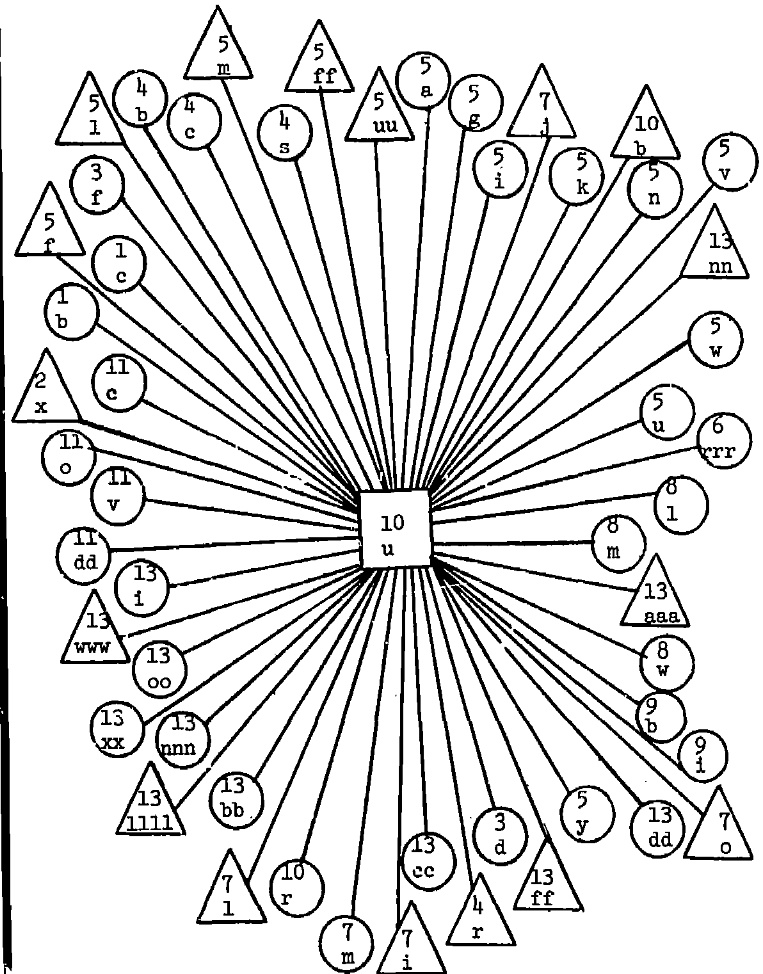

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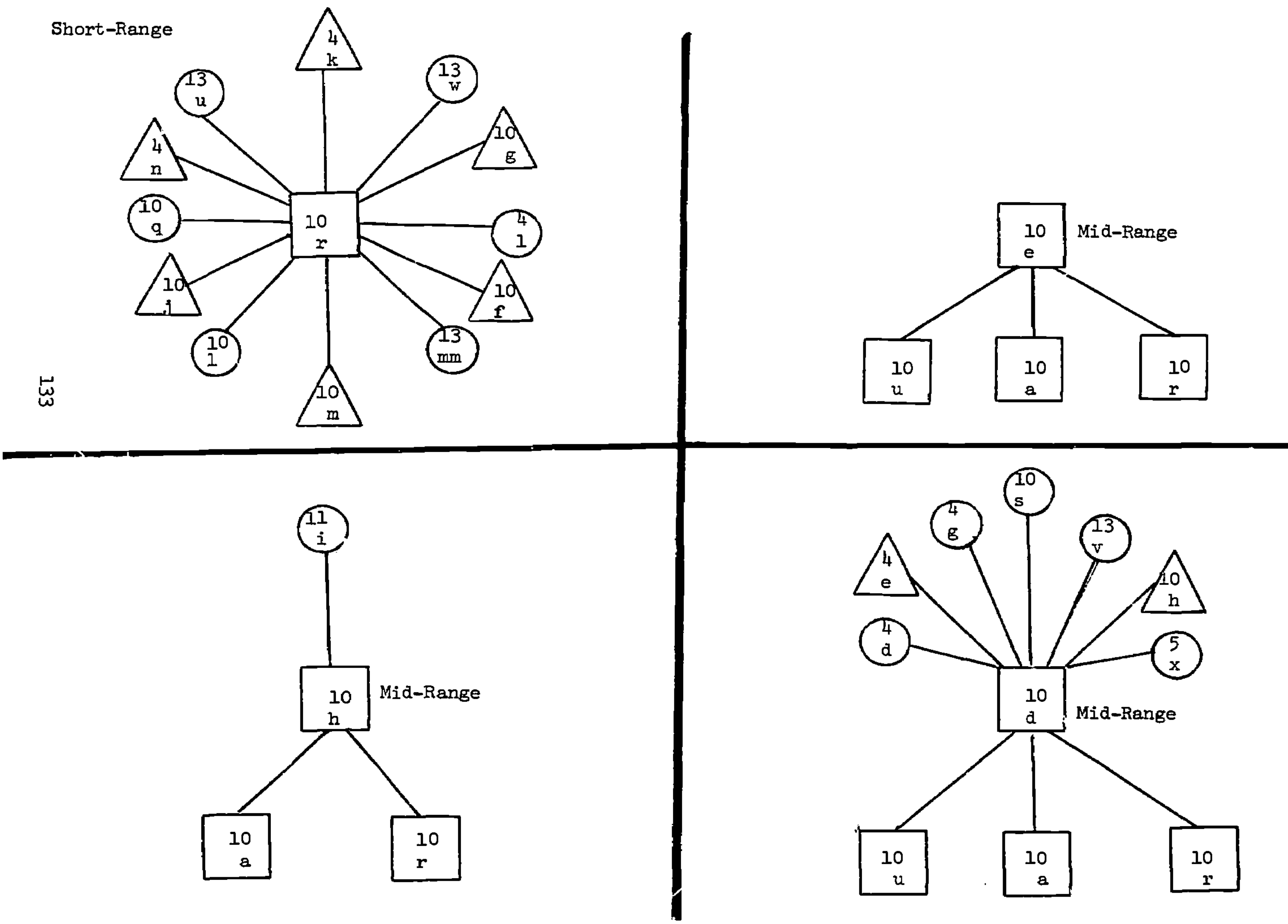
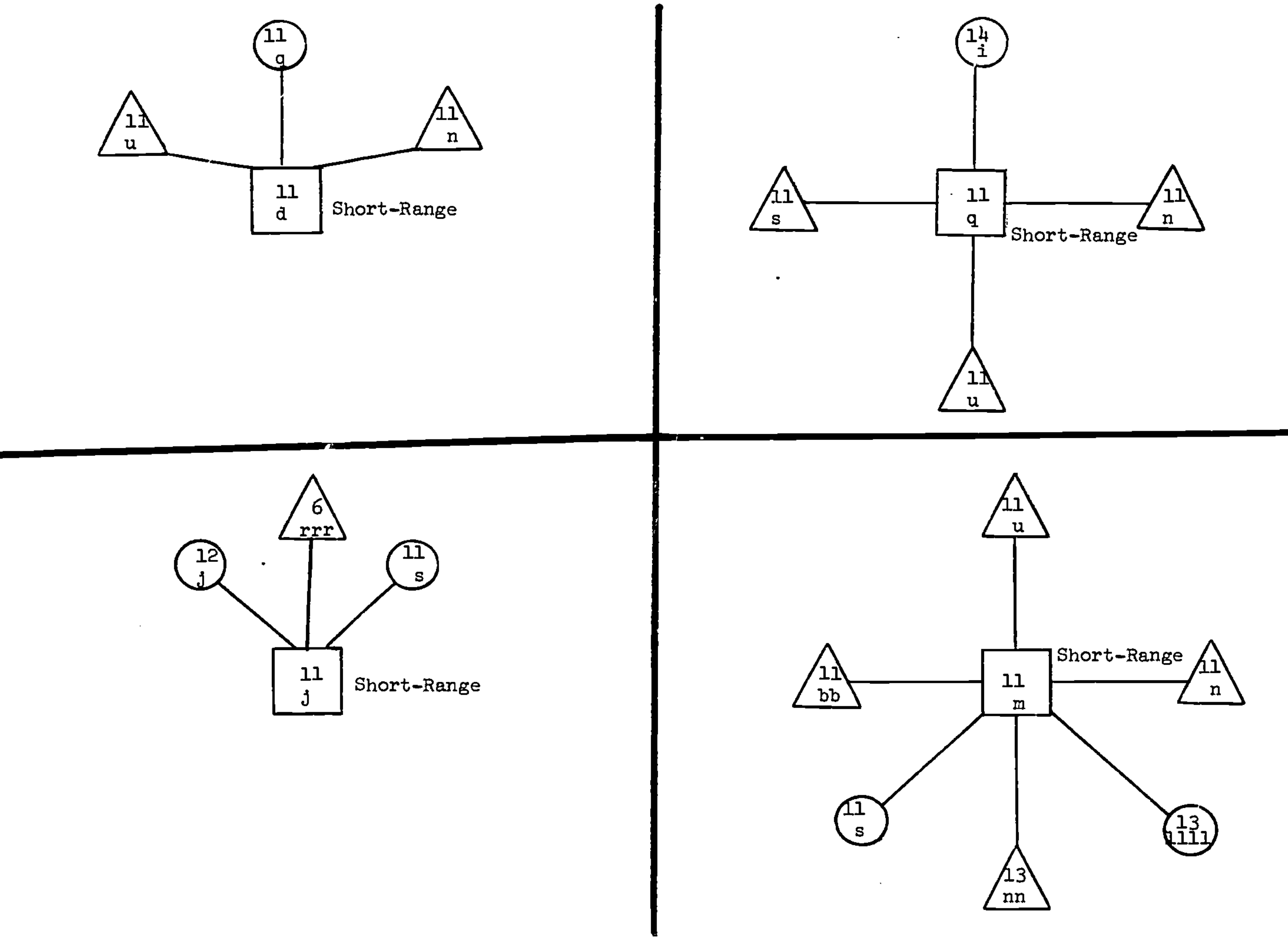

Short-Range
10 r
4 k
13 w
10 g
4 l
10 f
13 mm
10 m
10 l
10 j
10 q
4 n
13 u
Mid-Range
10 e
10 u
10 a
10 r
Mid-Range
10 h
11 i
10 a
10 r
Mid-Range
10 d
4 e
4 g
10 s
13 v
10 h
4 d
5 x
10 u
10 a
10 r


11
q
11
u
11
n
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d
Short-Range
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i
11
s
11
q
Short-Range
11
n
11
u
6
rrr
12
j
11
s
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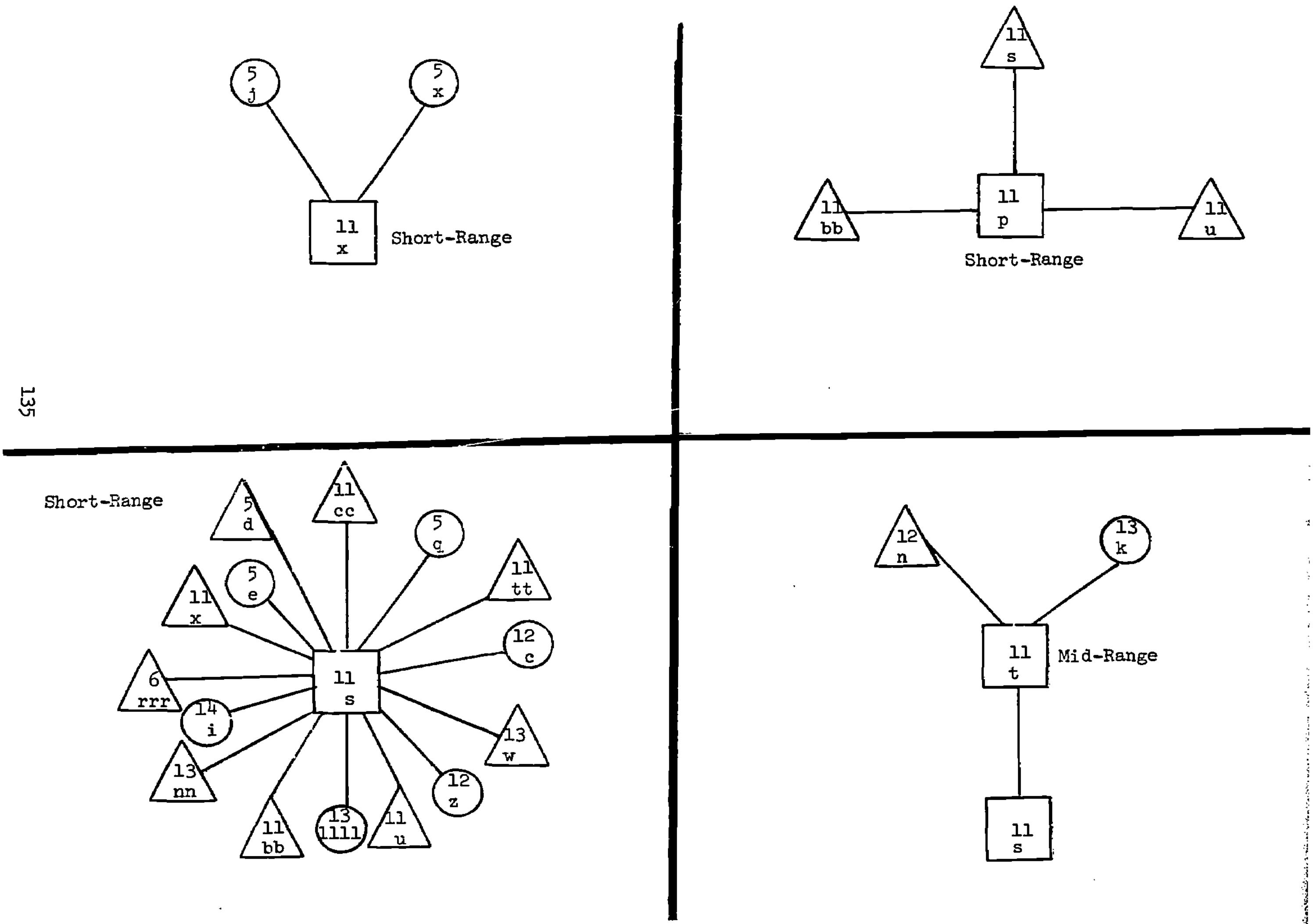
j
Short-Range
11
u
Short-Range
11
bb
11
m
11
n
11
s
13
nn
13
1111


5 j
5 x
11 x
Short-Range
11 s
11 bb
11 p
11 u
Short-Range
Short-Range
5 d
11 cc
5 q
11 tt
5 e
11 x
12 c
11 s
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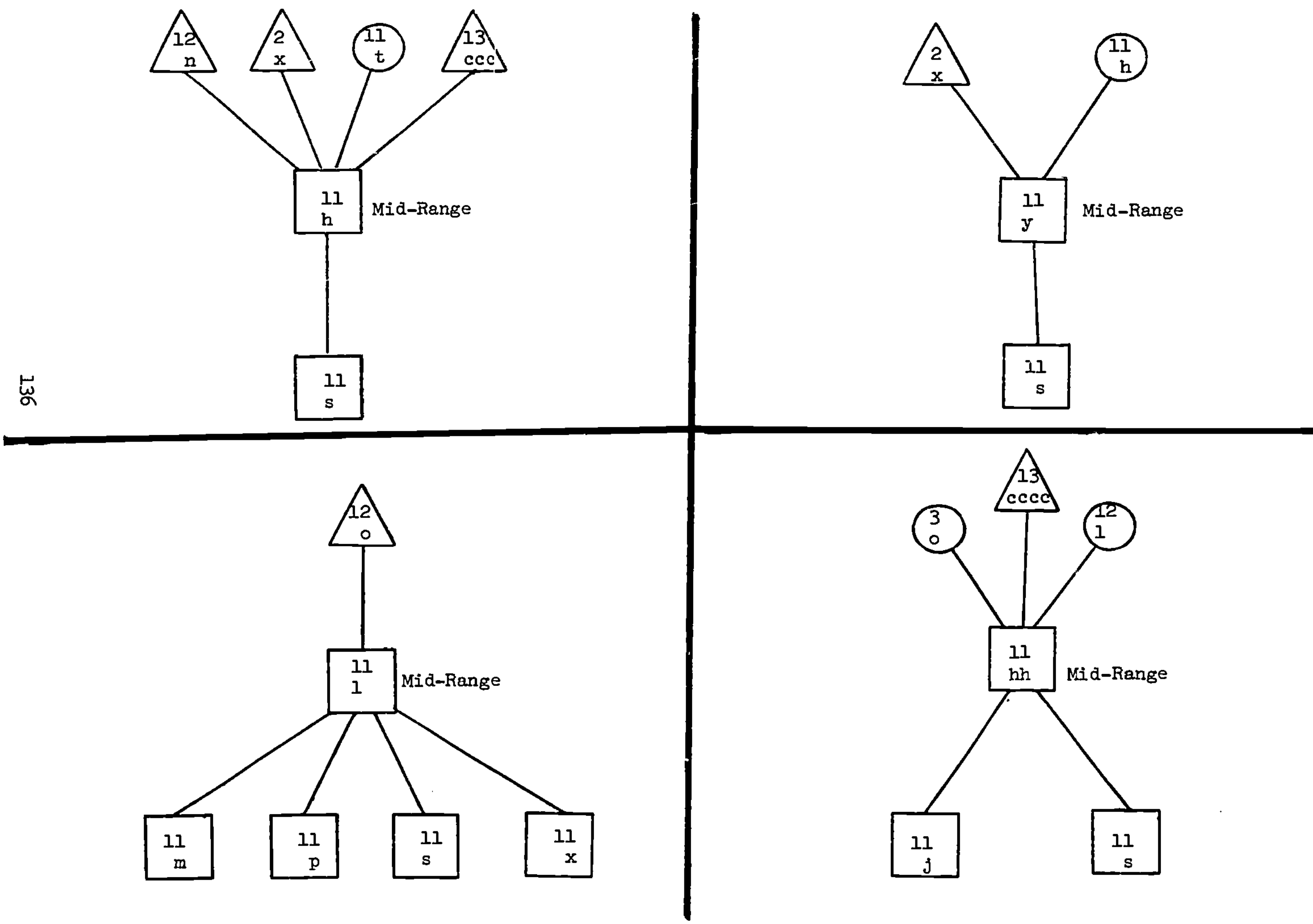
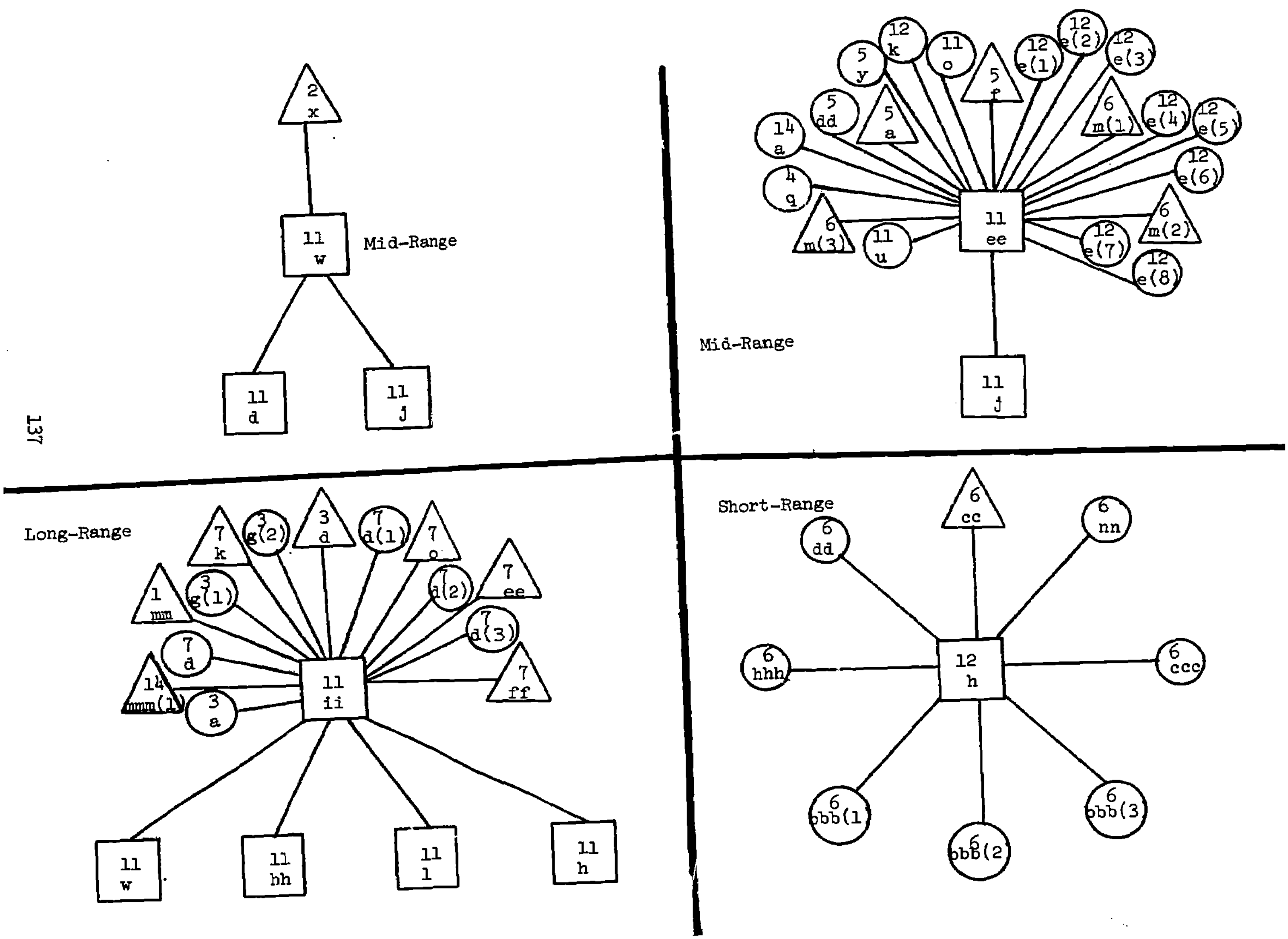
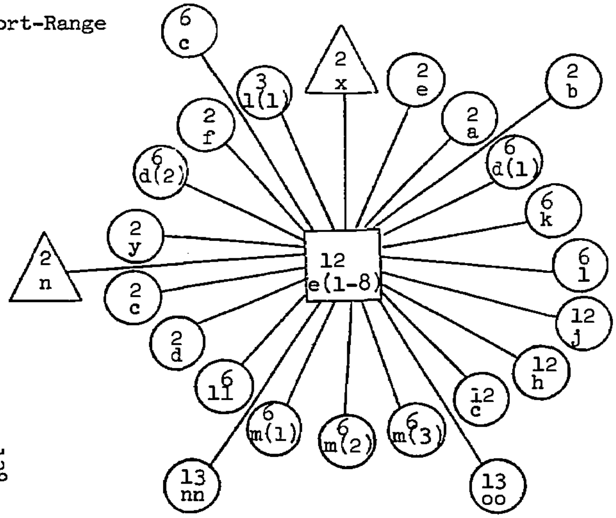
13 w
13 nn
12 z
11 bb
13 1111
11 u
12 n
13 k
11 t
Mid-Range
11 s


12 n
2 x
11 t
13 ccc
11 h
Mid-Range
11 s
2 x
11 h
11 y
Mid-Range
11 s
12 o
11 l
Mid-Range
11 m
11 p
11 s
11 x
3 o
13 cccc
12 l
11 hh
Mid-Range
11 j
11 s



2 x
11 w
Mid-Range
11 d
11 j
12 k
11 o
12 e(1)
12 e(2)
12 e(3)
5 y
5 f
5 dd
5 a
6 m(1)
12 e(4)
12 e(5)
14 a
12 e(6)
4 q
6 m(3)
11 u
11 ee
12 e(7)
6 m(2)
12 e(8)
Mid-Range
11 j
Long-Range
7 k
3 g(2)
3 d
7 d(1)
7 o
7 d(2)
7 ee
1 mm
3 g(1)
7 d(3)
7 d
14 mmm(1)
3 a
11 ii
7 ff
11 w
11 hh
11 l
11 h
Short-Range
6 cc
6 dd
6 nn
6 hhh
12 h
6 ccc
6 bbb(1)
6 bbb(2)
6 bbb(3)

Short-Range



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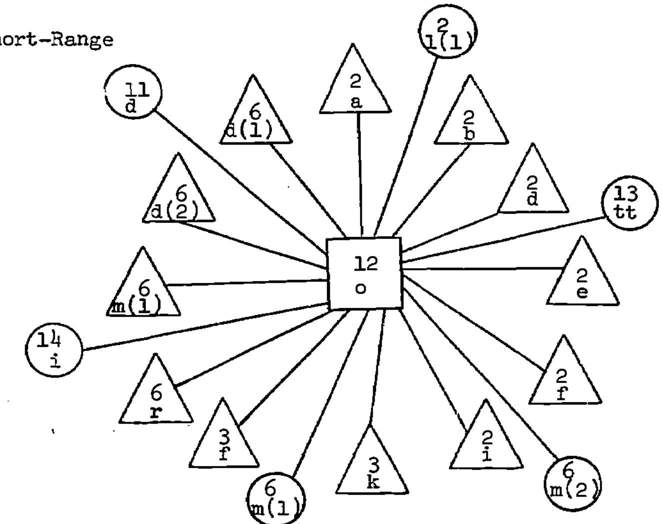

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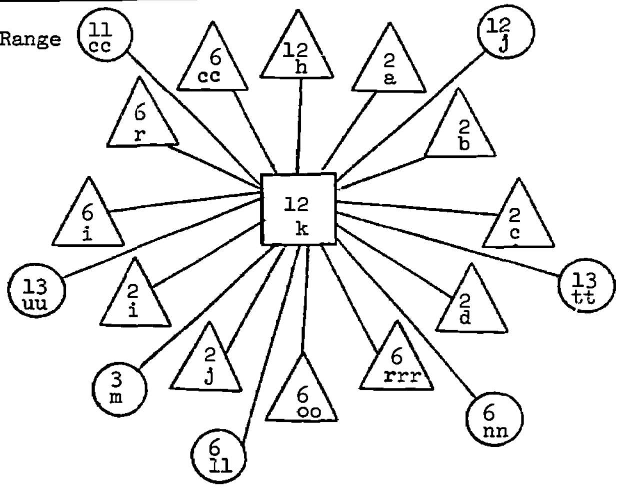

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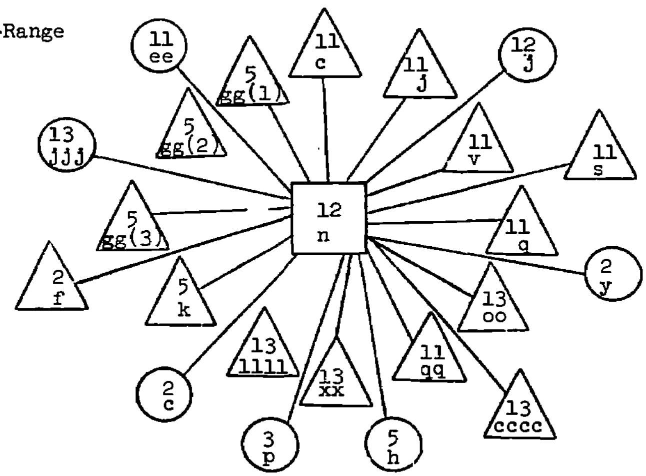
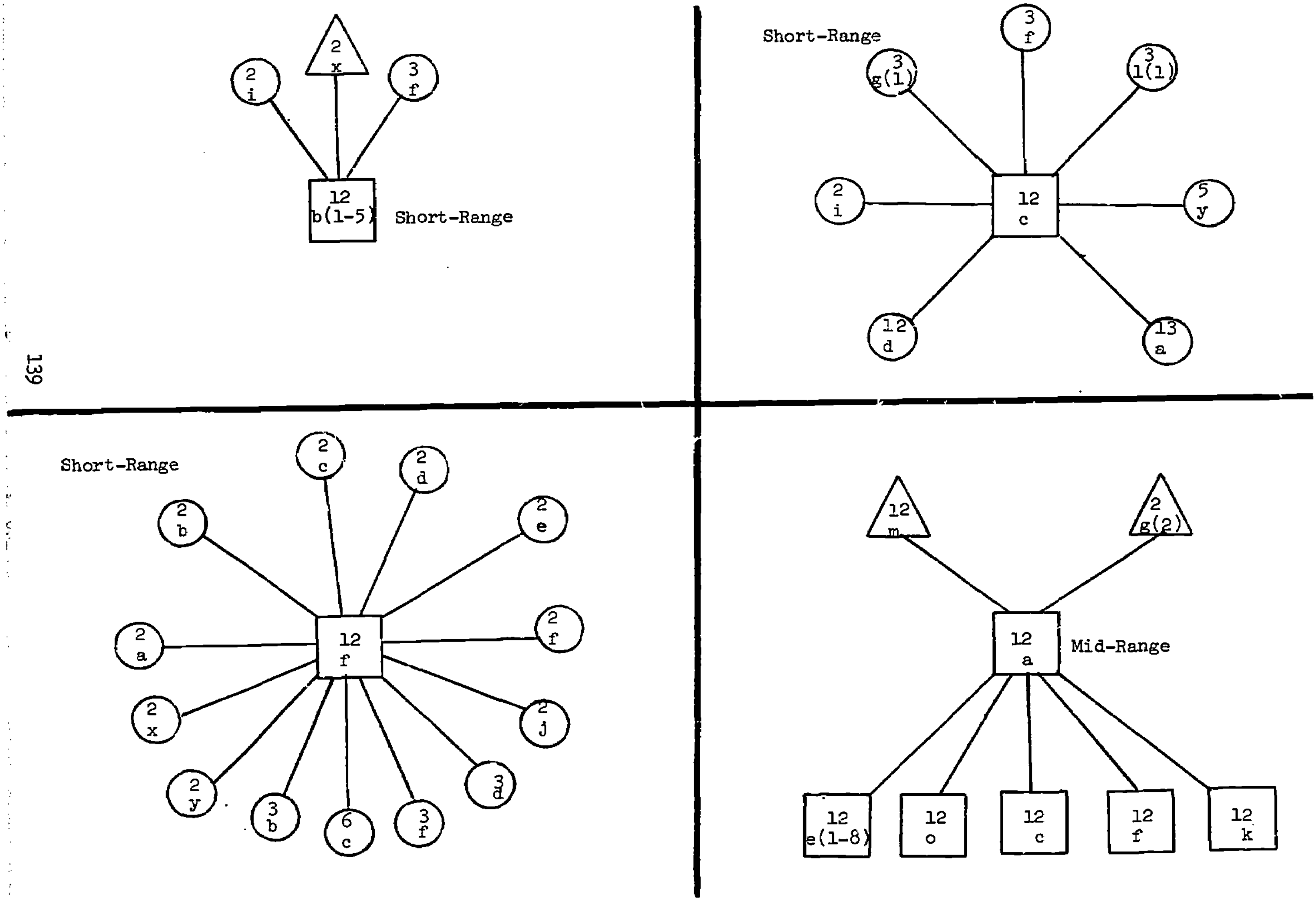
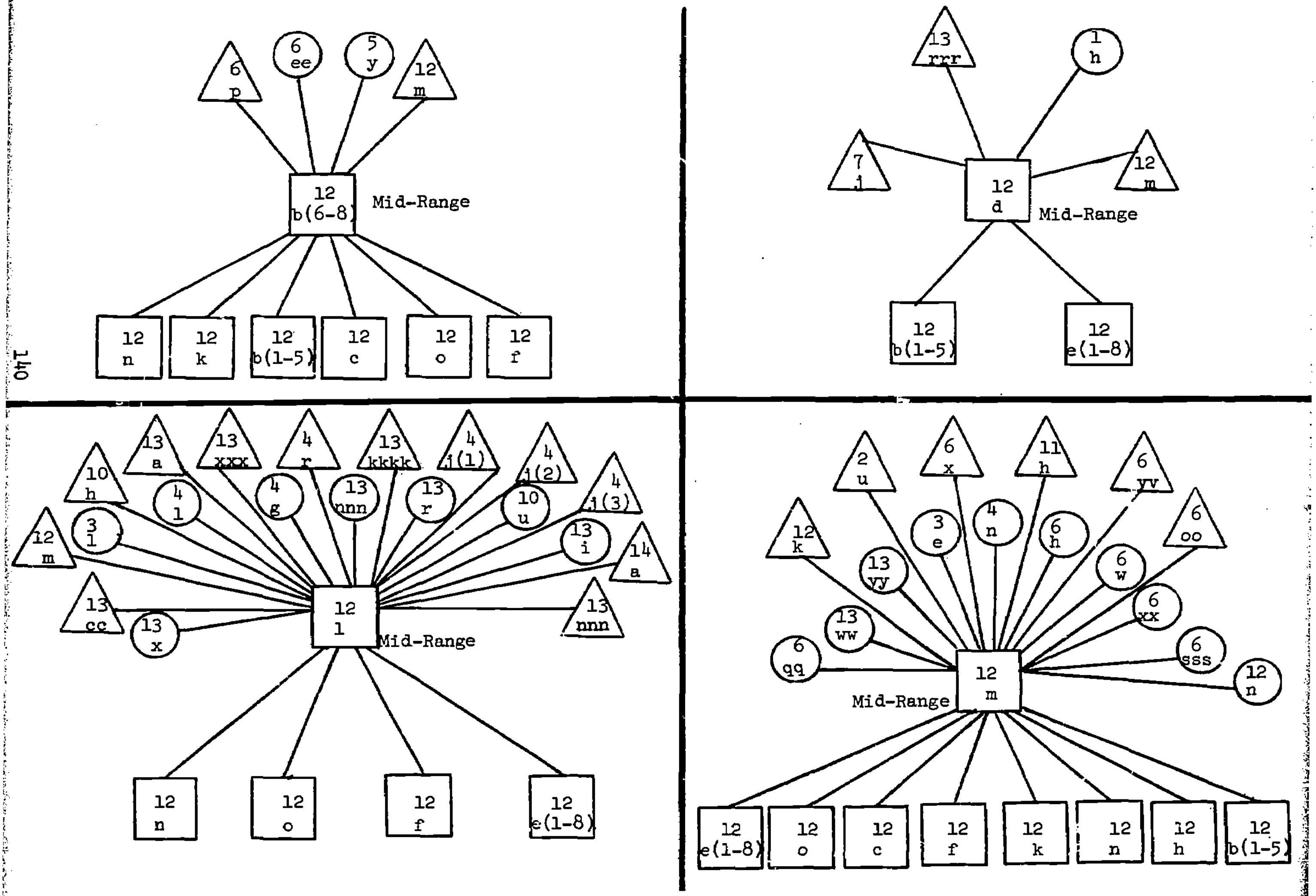
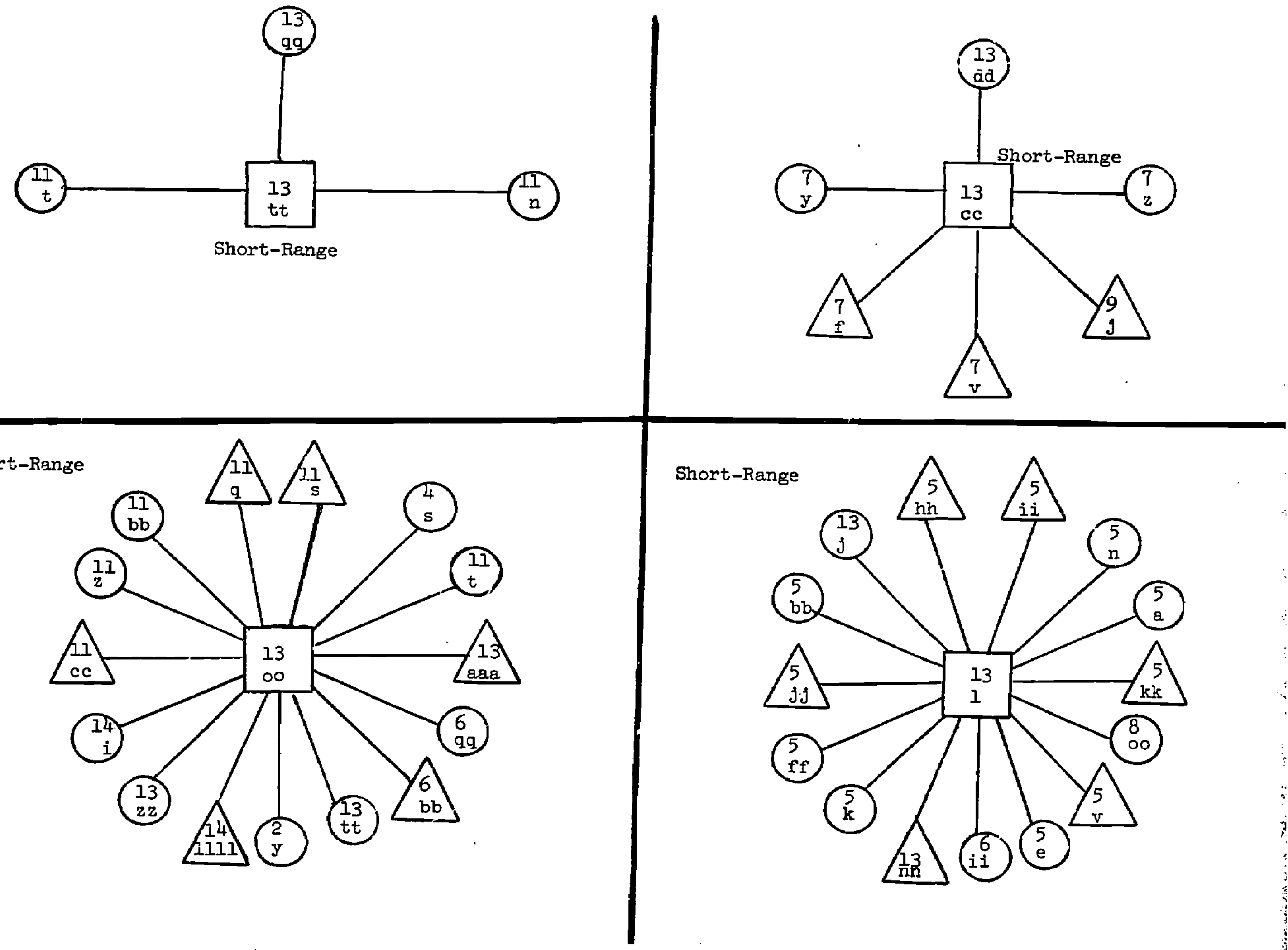




2
x
2
i
3
f
12
b(1-5)
Short-Range
Short-Range
3
f
3
g(1)
3
l(1)
2
i
12
c
5
y
12
d
13
a
Short-Range
2
c
2
d
2
b
2
e
2
a
12
f
2
f
2
x
2
j
2
y
3
d
3
b
6
c
3
f
12
m
2
g(2)
12
a
Mid-Range
12
e(1-8)
12
o
12
c
12
f
12
k

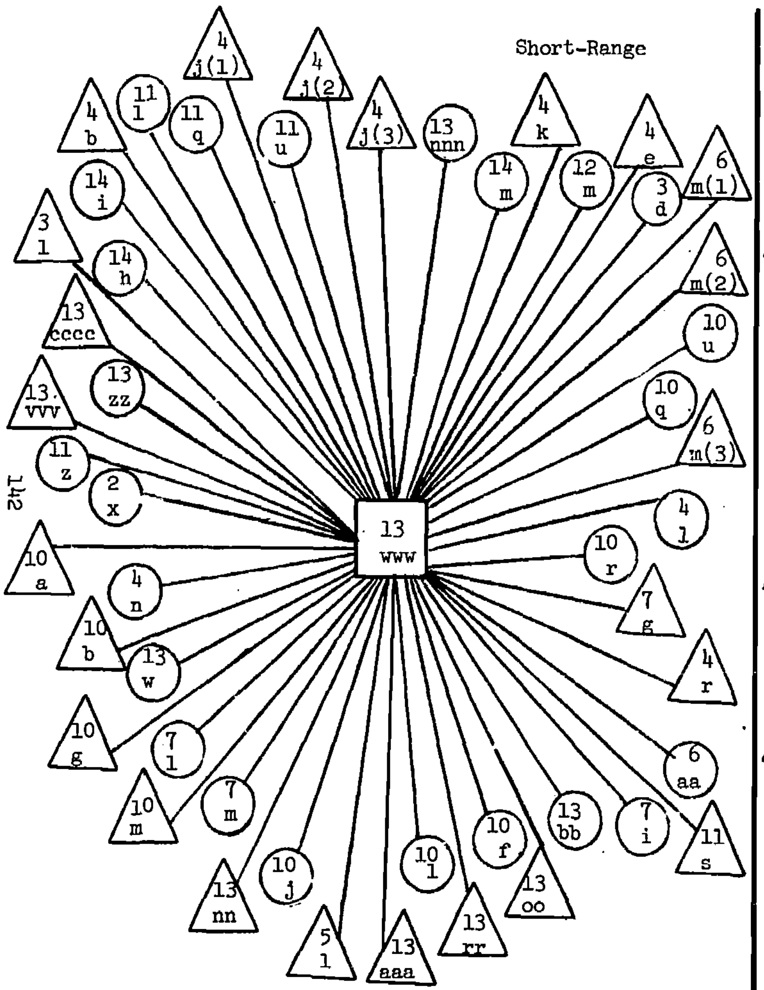


6 p
6 ee
5 y
12 m
12 b(6-8)
Mid-Range
12 n
12 k
12 b(1-5)
12 c
12 o
12 f
13 rrr
1 h
7 j
12 m
12 d
Mid-Range
12 b(1-5)
12 e(1-8)
10 h
13 a
13 xxx
4 r
13 kkkk
4 j(1)
4 j(2)
4 j(3)
4 l
4 g
13 nnn
13 r
10 u
13 i
14 a
12 m
3 l
13 cc
13 x
12 l
Mid-Range
13 nnn
12 n
12 o
12 f
12 e(1-8)
2 u
6 x
11 h
6 yv
12 k
3 e
4 n
6 h
6 oo
13 yy
6 w
6 xx
13 ww
6 qq
6 sss
12 n
12 m
Mid-Range
12 e(1-8)
12 o
12 c
12 f
12 k
12 n
12 h
12 b(1-5)



13 qq
11 t
13 tt
11 n
Short-Range
13 dd
Short-Range
7 y
13 cc
7 z
7 f
7 v
9 j
Short-Range
11 q
11 s
11 bb
4 s
11 z
11 t
11 cc
13 oo
13 aaa
14 i
6 qq
13 zz
14 llll
2 y
13 tt
6 bb
Short-Range
5 hh
5 ii
13 j
5 n
5 bb
5 a
5 jj
13 l
5 kk
5 ff
8 oo
5 k
5 v
13 nn
6 ii
5 e

Short-Range



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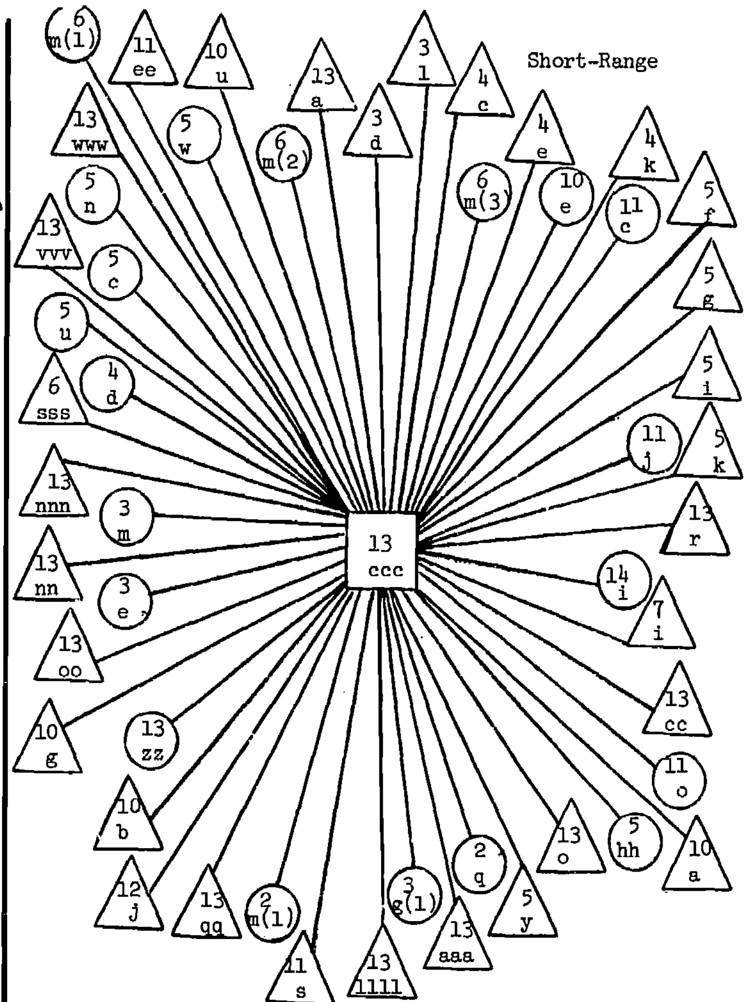
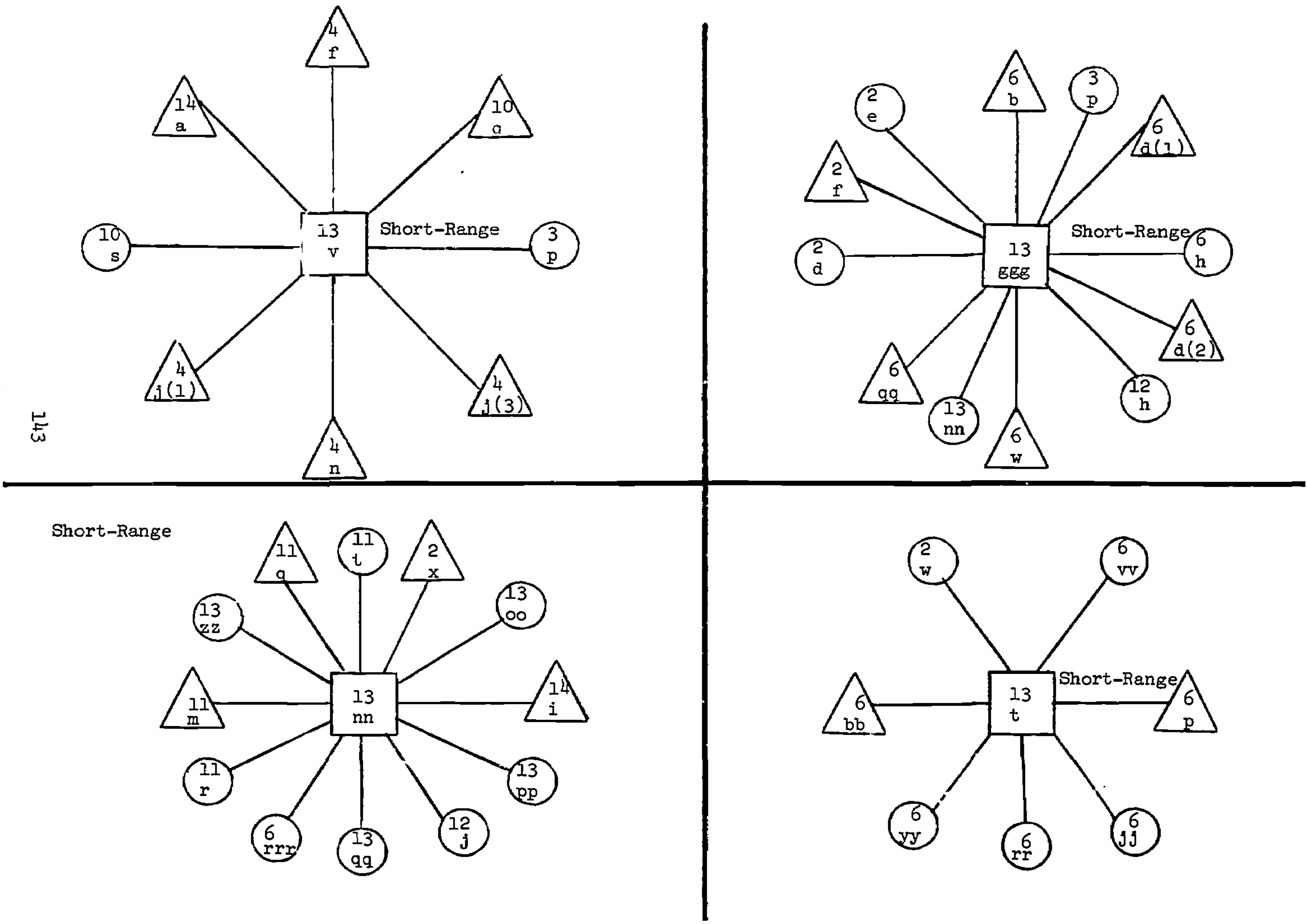
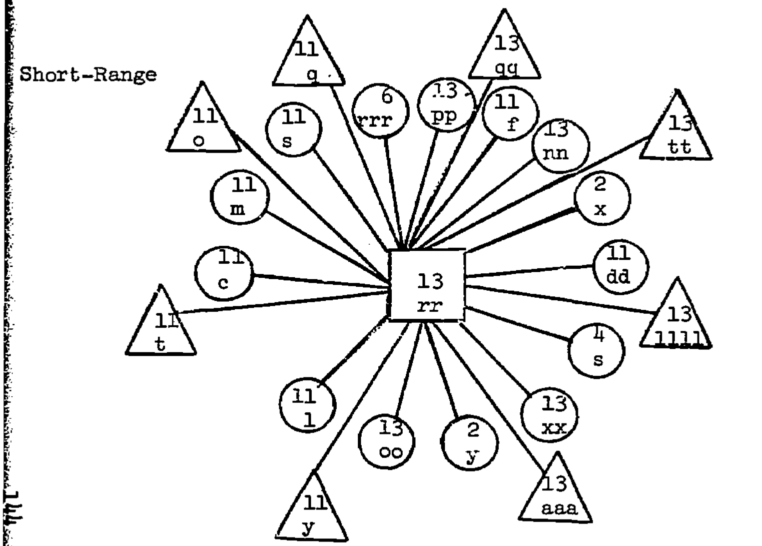



Short-Range
13 v
4 f
14 a
10 q
10 s
3 p
4 j(1)
4 j(3)
4 n
Short-Range
13 ggg
2 e
6 b
3 p
6 d(1)
2 f
2 d
6 h
6 qq
13 nn
6 w
12 h
6 d(2)
Short-Range
13 nn
11 q
11 t
2 x
13 zz
13 oo
11 m
14 i
11 r
13 pp
6 rrr
13 qq
12 j
Short-Range
13 t
2 w
6 vv
6 bb
6 p
6 yy
6 rr
6 jj


Short-Range
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rr
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q
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qq
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o
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s
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rrr
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pp
11
f
13
nn
13
tt
11
m
2
x
11
c
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1111
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s
11
l
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oo
2
y
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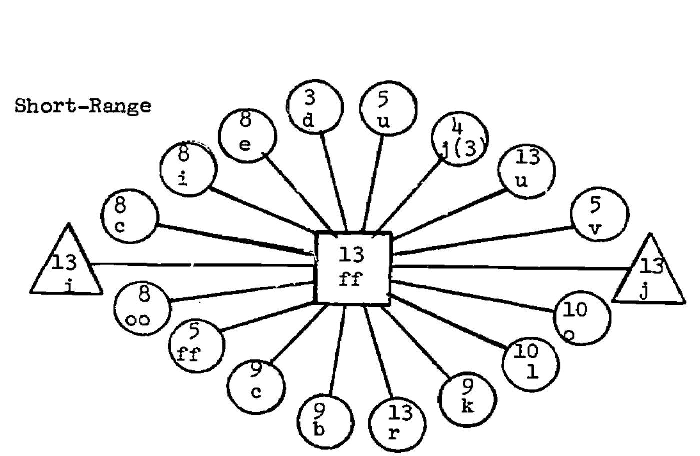
xx
11
y
13
aaa


Short-Range
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ff
3
d
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u
8
e
4
j(3)
8
i
13
u
8
c
5
v
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oo
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o
5
ff
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l
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c
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b
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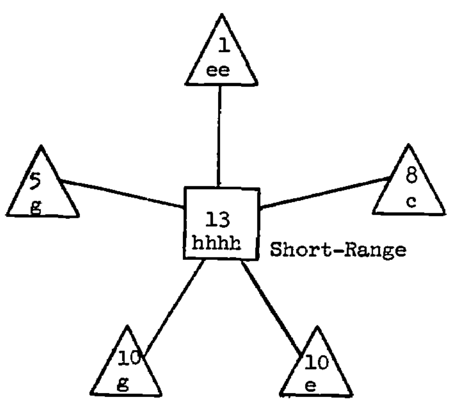
r
9
k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g
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c
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Short-Range
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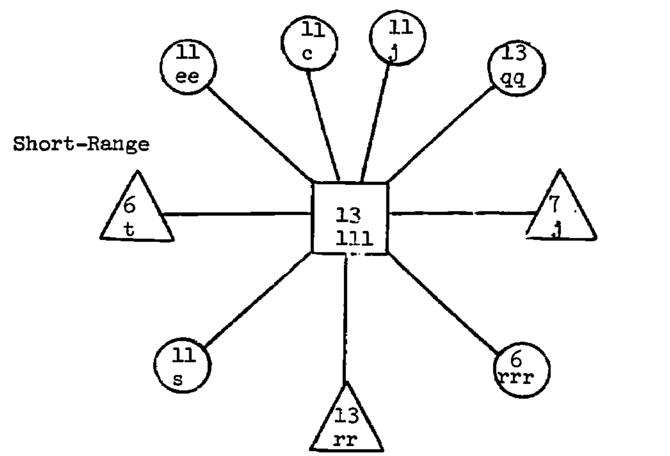
g
10
e


Short-Range
11
ee
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c
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j
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qq
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t
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111
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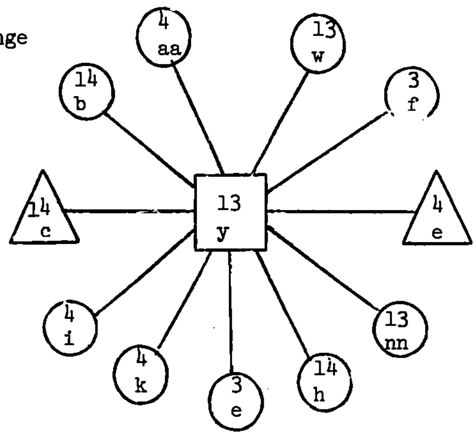
j
11
s
6
rrr
13
rr

Short-Range



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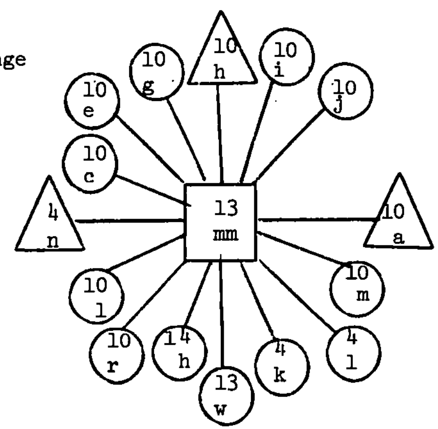

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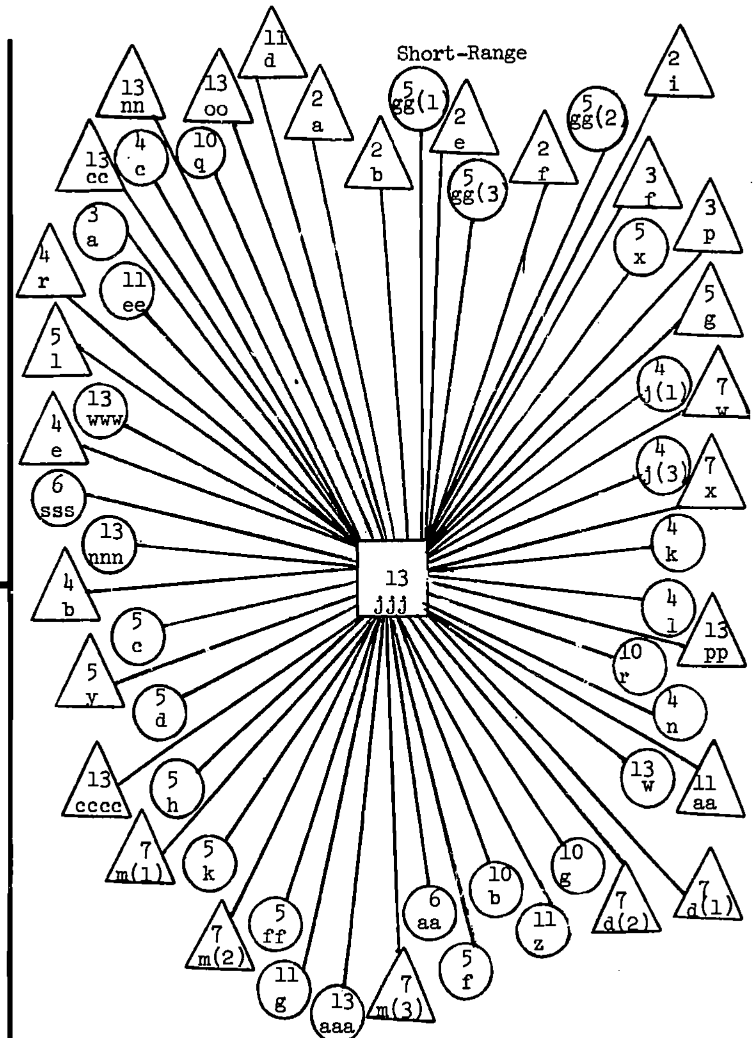

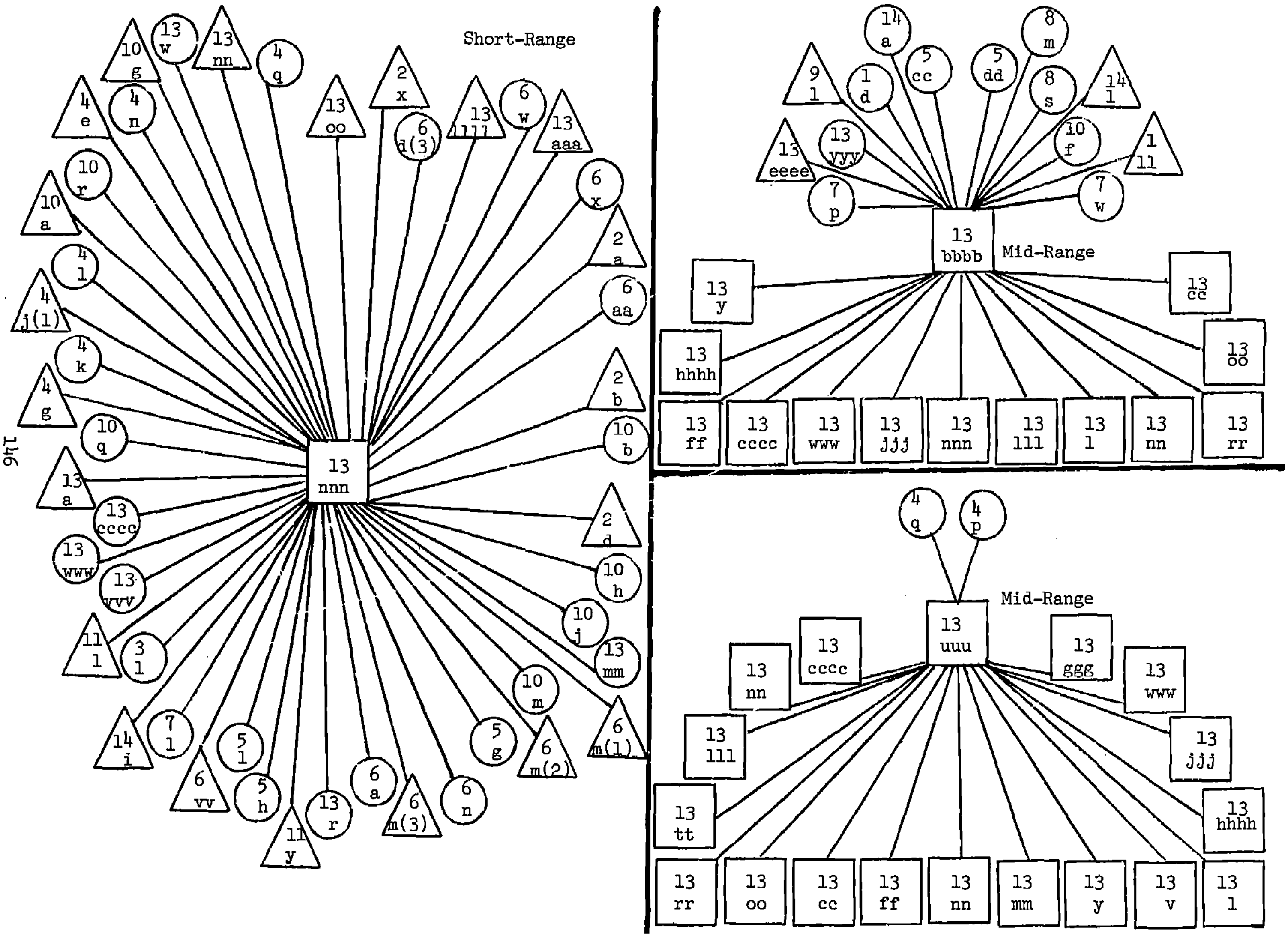
Short-Range
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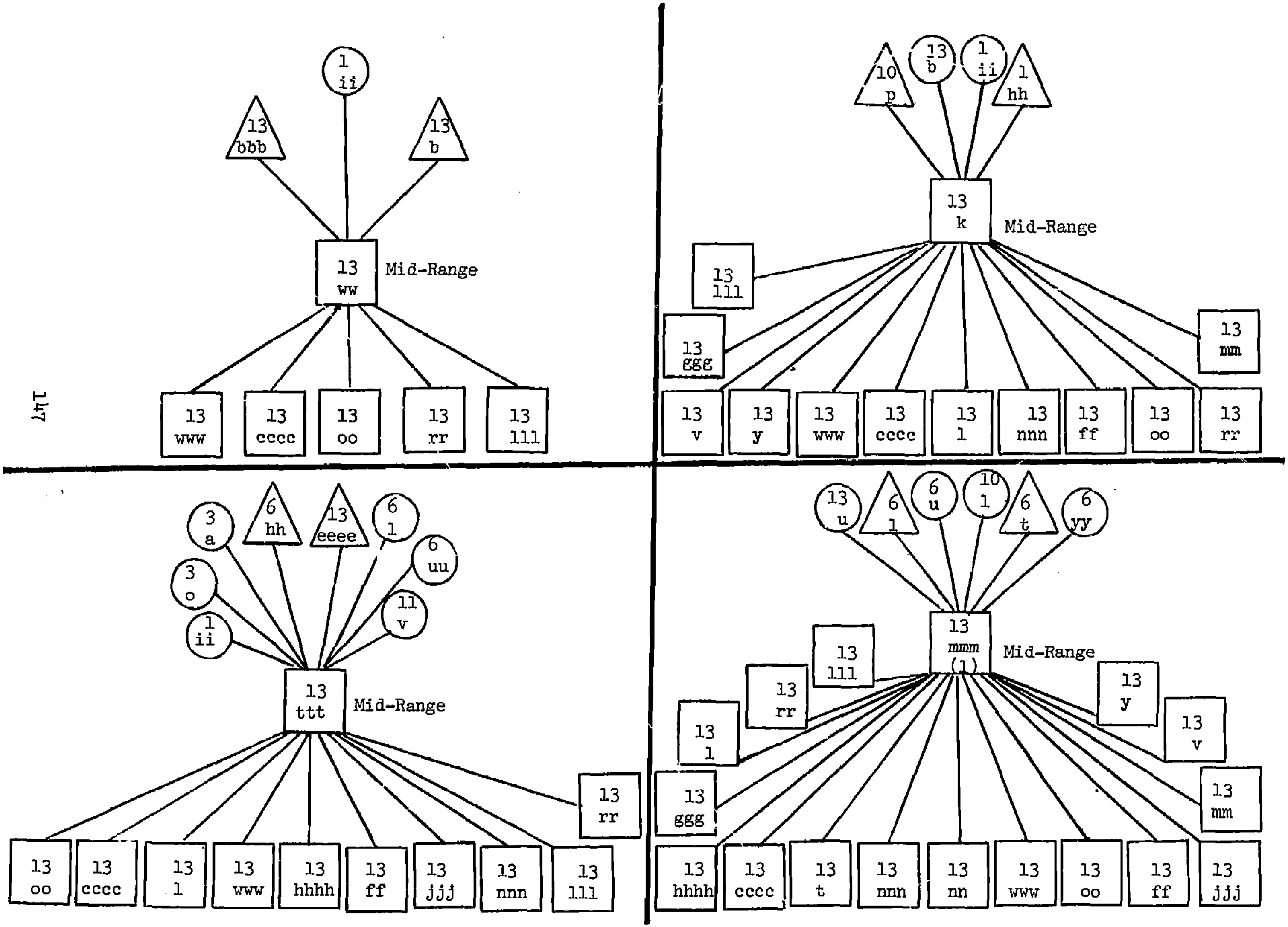
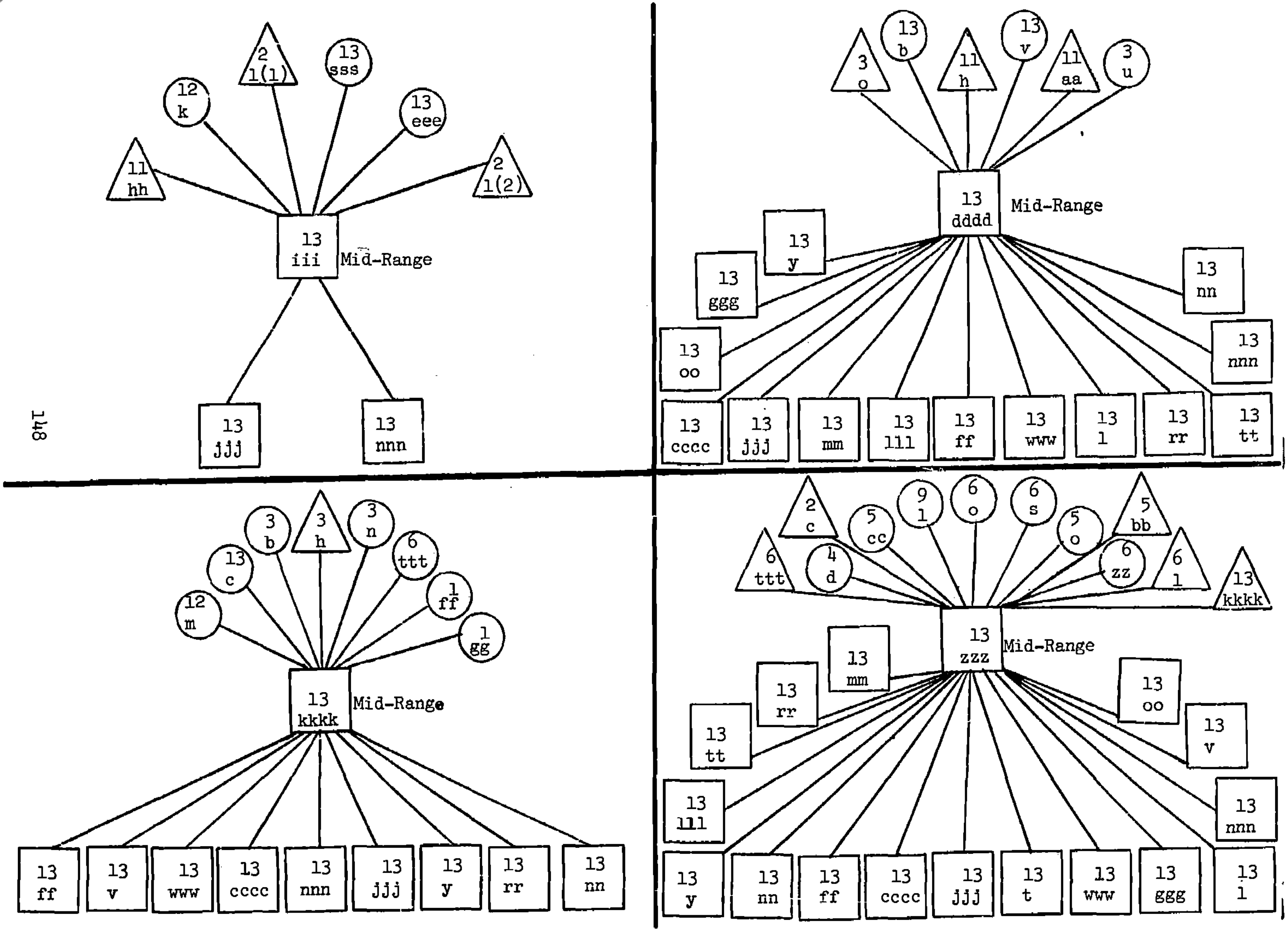
Mid-Range
13 bbbb
Mid-Range
13 uuu


13 bbb
1 ii
13 b
13 ww
Mid-Range
13 www
13 cccc
13 oo
13 rr
13 111
10 p
13 b
1 ii
1 hh
13 k
Mid-Range
13 111
13 ggg
13 mm
13 v
13 y
13 www
13 cccc
13 l
13 nnn
13 ff
13 oo
13 rr
3 a
6 hh
13 eeee
6 l
6 uu
3 o
11 v
1 ii
13 ttt
Mid-Range
13 rr
13 oo
13 cccc
13 l
13 www
13 hhhh
13 ff
13 jjj
13 nnn
13 111
13 u
6 l
6 u
10 l
6 t
6 yy
13 mmm (1)
Mid-Range
13 111
13 rr
13 y
13 l
13 v
13 ggg
13 mm
13 hhhh
13 cccc
13 t
13 nnn
13 nn
13 www
13 oo
13 ff
13 jjj


13 iii
Mid-Range
11 hh
12 k
2 1(1)
13 sss
13 eee
2 1(2)
13 jjj
13 nnn
13 dddd
Mid-Range
3 o
13 b
11 h
13 v
11 aa
3 u
13 y
13 ggg
13 oo
13 cccc
13 jjj
13 mm
13 111
13 ff
13 www
13 1
13 rr
13 tt
13 nnn
13 nn
13 kkkk
Mid-Range
12 m
13 c
3 b
3 h
3 n
6 ttt
1 ff
1 gg
13 ff
13 v
13 www
13 cccc
13 nnn
13 jjj
13 y
13 rr
13 nn
13 zzz
Mid-Range
6 ttt
2 c
4 d
5 cc
9 1
6 o
6 s
5 o
5 bb
6 zz
6 1
13 kkkk
13 mm
13 rr
13 tt
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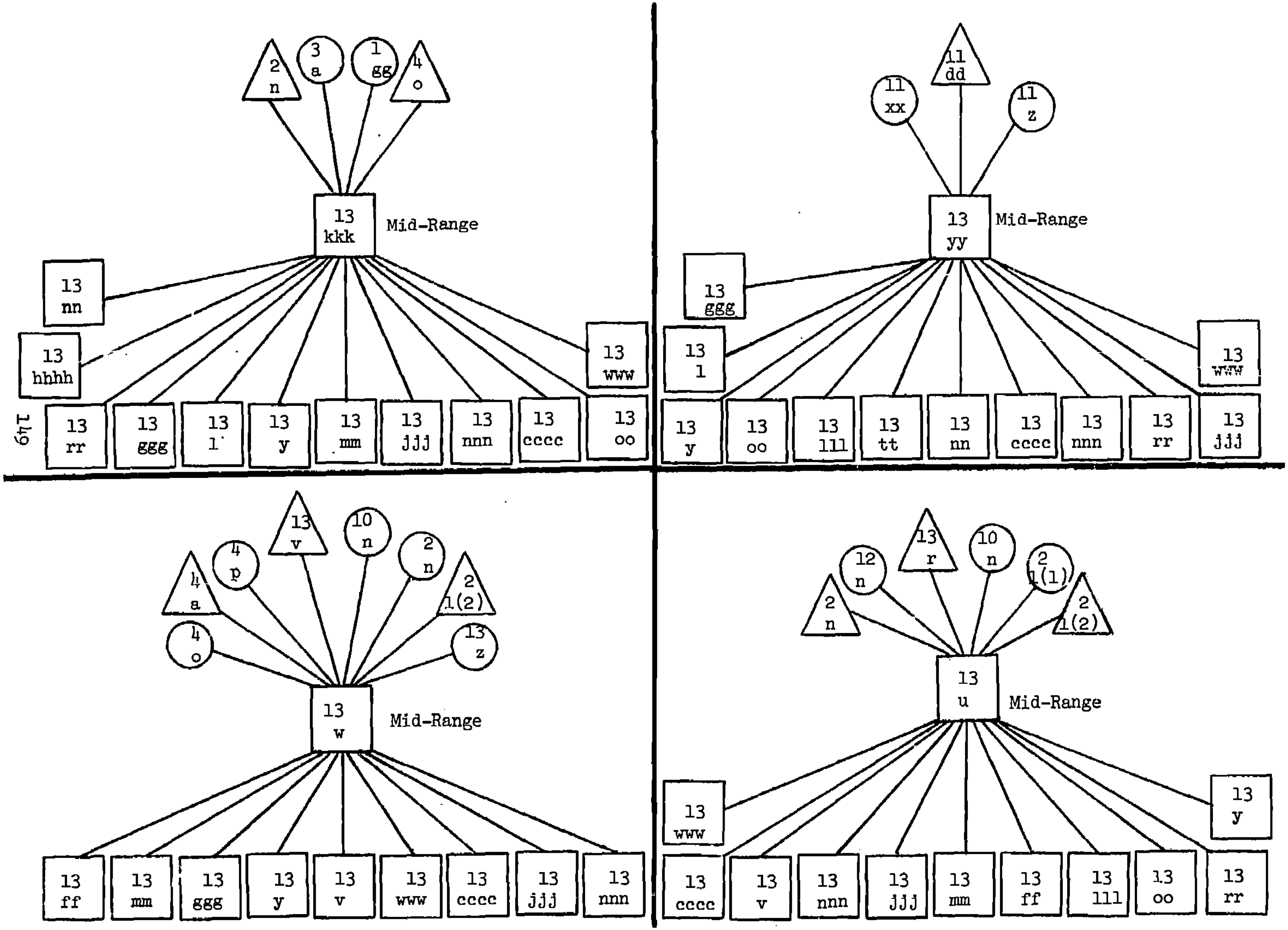
13 nnn
13 v
13 oo



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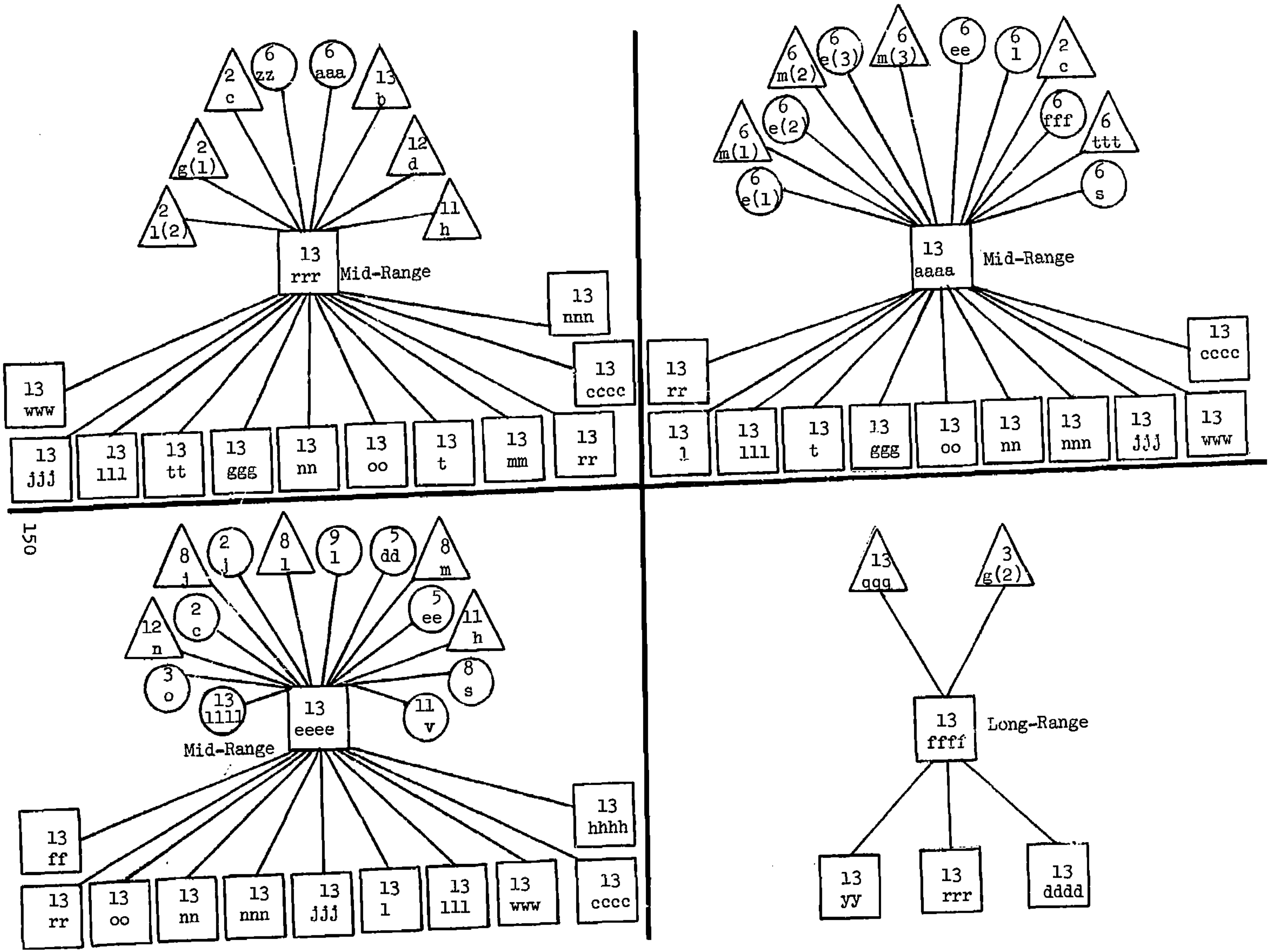
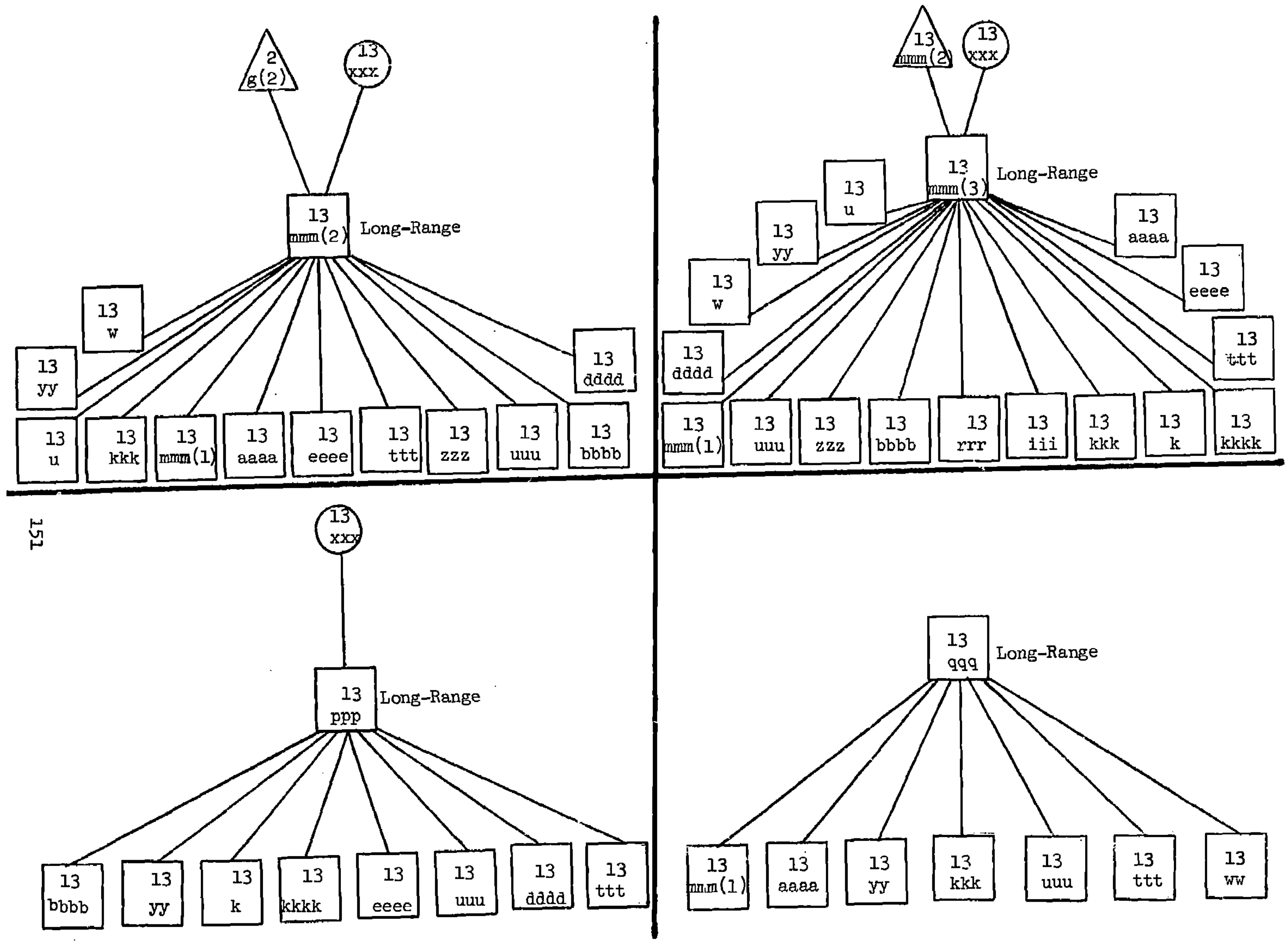
3 a
1 gg
4 o
13 kkk
Mid-Range
13 nn
13 hhhh
13 rr
13 ggg
13 l
13 y
13 mm
13 jjj
13 nnn
13 cccc
13 www
13 oo
11 xx
11 dd
11 z
13 yy
Mid-Range
13 ggg
13 l
13 y
13 oo
13 lll
13 tt
13 nn
13 cccc
13 nnn
13 rr
13 www
13 jjj
4 a
4 o
4 p
13 v
10 n
2 n
2 l(2)
13 z
13 w
Mid-Range
13 ff
13 mm
13 ggg
13 y
13 v
13 www
13 cccc
13 jjj
13 nnn
2 n
12 n
13 r
10 n
2 l(1)
2 l(2)
13 u
Mid-Range
13 www
13 cccc
13 v
13 nnn
13 jjj
13 mm
13 ff
13 lll
13 oo
13 y
13 rr


2 c
6 zz
6 aaa
13 b
2 g(1)
12 d
2 l(2)
11 h
13 rrr
Mid-Range
13 nnn
13 www
13 cccc
13 jjj
13 lll
13 tt
13 ggg
13 nn
13 oo
13 t
13 mm
13 rr
6 m(2)
6 e(3)
6 m(3)
6 ee
6 l
2 c
6 e(2)
6 fff
6 m(1)
6 ttt
6 e(1)
6 s
13 aaaa
Mid-Range
13 rr
13 cccc
13 l
13 lll
13 t
13 ggg
13 oo
13 nn
13 nnn
13 jjj
13 www
8 i
2 j
8 l
9 l
5 dd
8 m
12 n
2 c
5 ee
11 h
3 o
13 llll
8 s
13 eeee
11 v
Mid-Range
13 ff
13 hhhh
13 rr
13 oo
13 nn
13 nnn
13 jjj
13 l
13 lll
13 www
13 cccc
13 qqq
3 g(2)
13 ffff
Long-Range
13 yy
13 rrr
13 dddd


2 g(2)
13 xxx
13 mmm(2) Long-Range
13 w
13 yy
13 u
13 kkk
13 mmm(1)
13 aaaa
13 eeee
13 ttt
13 zzz
13 uuu
13 bbbb
13 dddd
13 mmm(2)
13 xxx
13 mmm(3) Long-Range
13 u
13 yy
13 w
13 dddd
13 mmm(1)
13 uuu
13 zzz
13 bbbb
13 rrr
13 iii
13 kkk
13 k
13 kkkk
13 ttt
13 eeee
13 aaaa
13 xxx
13 ppp Long-Range
13 bbbb
13 yy
13 k
13 kkkk
13 eeee
13 uuu
13 dddd
13 ttt
13 qqq Long-Range
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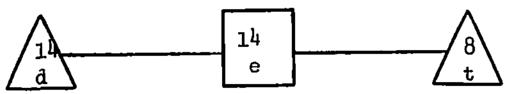
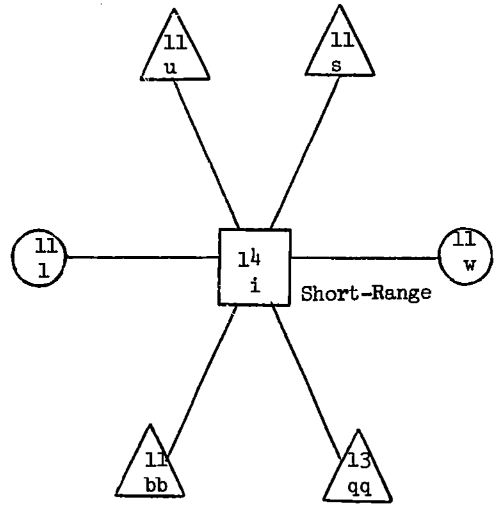
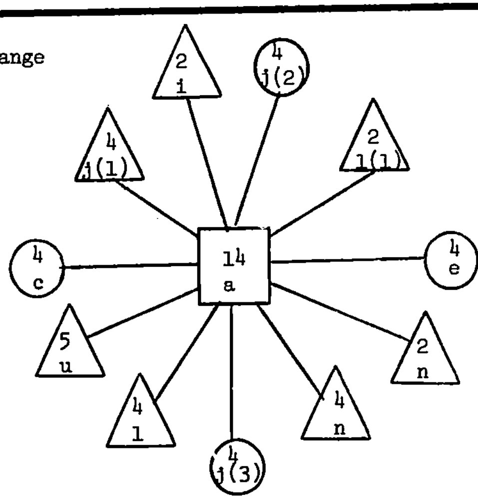
13 aaaa
13 yy
13 kkk
13 uuu
13 ttt
13 ww

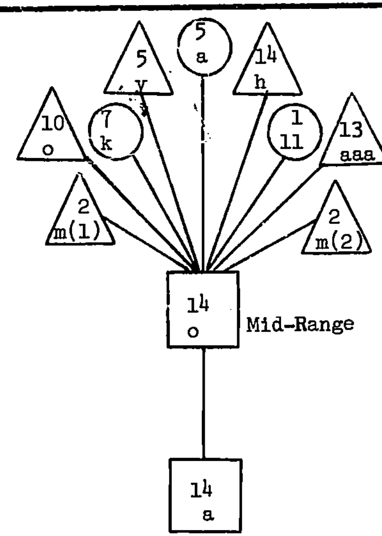


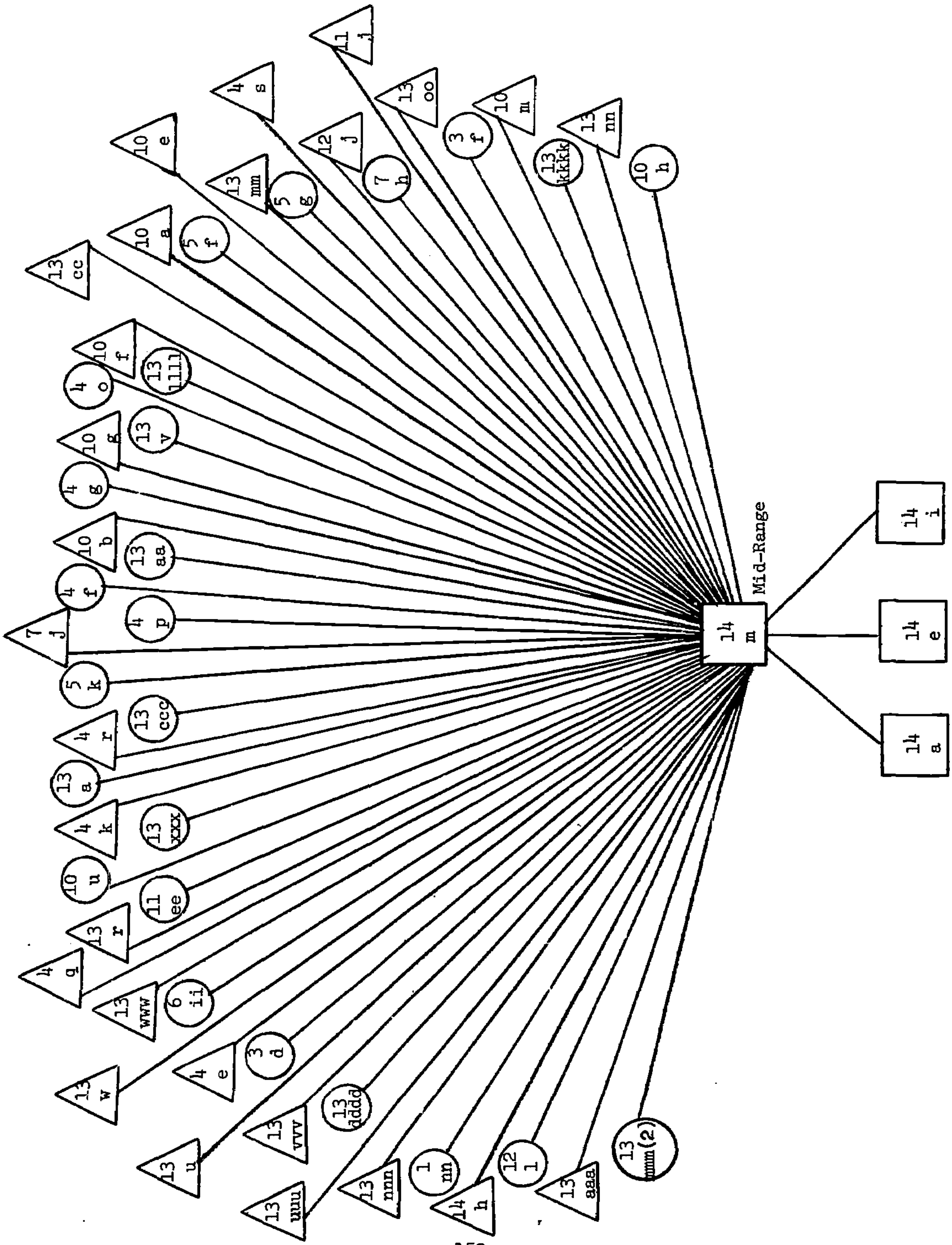
Short-Range



Short-Range



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CHAPTER V

CONCLUDING REMARKS

A. Summary

This forecast was conditioned vis á vis a user requirements orientation. This permitted the highlighting of technological gaps and unexploited capabilities. Little in the way of gaps in hardware technology was detected. The exceptions are in the areas of input and communications. These gaps will be substantially overcome during the next five years. The forecast indicates that the next five years in information-processing will bring nothing revolutionary in terms of hardware, only more efficient use of current types of equipment. The exceptions here will be in the widespread use of pattern recognition and source data automation devices. Lack of uniformity in equipments and procedures is the major gap. For example, on several occasions NAVSUP found at an individual activity different equipment and procedures being used for identical tasks. This introduces such inefficiencies as duplication, time-lag, syntax errors, and logical errors. To sum it up, the gaps are not in hardware technology, but in the application of technology to user needs.

If technological gaps are basically closed, why continue to forecast information-processing technology? The reasons are that such forecasts permit us to find more efficient ways of doing things; to direct technology; and to perhaps provide hints of potential breakthroughs. Such an approach enables system designers to anticipate technology facilitating a modular approach to accept new technology without requiring total redesign.

During its infancy and early formative years, information-processing technology required and received substantial Government cultivation. The Navy has taken, and is continuing to take, an active role in support of the advancement of this technology. Navy decision-makers have chosen to emphasize support of R&D efforts in information-processing technology in the tactical environment, e.g., missile guidance systems, etc. The Navy has given substantial indirect support to industry's R&D efforts through large-scale purchases of newly developed gear for use in conducting a wide range of support functions. In fact, buys of this nature are used to write-off industry R&D investment lowering economic barriers to advancing technology.

The comparison between hardware technology and Navy user requirements discussed in Chapter II of this paper clearly underscores the fact that a hiatus does exist in information-processing technology -- a gap in learning how to efficiently utilize and effectively manage the utilization of the hardware, rather than how to make it. If the Navy wishes to continue in its tradition of providing worthwhile support to the advancement of this technology and to reap increased benefits from its application, a reallocation of exploratory R&D resources should be instituted.

Making this change will require a difficult decision. Success after success has been recorded in the hardware and, to a measurable extent, software aspects of the problem. Yet, efforts to date in the areas of man-machine interface, machine-machine interface, and interactive impacts upon human organizations and machine organizations have been extremely disheartening and have met with painfully slow progress. Given these circumstances, it is only natural that R&D funding would be concentrated where the probability of success is high -- hardware and software technology.

Quantum improvements in information-processing technology are no longer likely to be made through the brute force approaches we have been taking in the past, e.g., faster computer cycle times and more sophisticated program language repertoires. Yet, such achievements are possible if we can take advantage of current and improving technology and add the missing ingredient -- total communication, i.e., be it man/man, man/machine, or machine/machine.

To achieve total communications, at least the following four areas must be stressed:

- Satisfaction of user requirements -

  In order to exploit technology and properly utilize technological potential, user requirements must be satisfied in terms of functions performed, not procedures used to perform them. This might cause major disruptive changes in current management practices and forms of human organization, yet offers potentially great payoffs.

- Standardization of procedures, equipment, software, and data elements -

  The lack of such standardization is the major source of current data handling problems. Such a program would create numerous casualties among vendors, programs, and current policies.

- Make the gear an extension of the man -

  For years lip service has been paid to this concept, while a diametrically opposed policy has been pursued. Today, we communicate with the machine in a manner more amenable to the machine than the man. If this extension concept is to be implemented, the machine must be prepared to converse with man through his natureal senses (such as sight and hearing) in his operating mode, i.e., an interactive question and answer experience.

- Adopt new ways of organizing the machine and systems of machines -

  Traditionally, information-processing gear has been organized as man says he thinks, sequentially. Yet, the human thinking process is really a combination of sequential and parallel processes couched in an essentially sequential master program. The ability to process data in such a manner is dependent upon the availability of a form of mathematics currently not available. However, given this breakthrough, the machine's part in achieving the total communication goal could be played ever more effectively.

B. Diagnosis and Prognosis

Seven shortcomings to the DELPHI technique (as currently envisaged) were enumerated in Chapter III above. SEER addressed itself to the satisfactory handling of six of these shortcomings, specifically:

1. A set of sample potential events was developed from interviews and secondary sources. This set of sample events was structured into technological sub-categories of information-processing and provided a starting point for Round I participants. In addition, these events served as control questions used to validate participant response.

2. The study design provided for two iterations. Each round involved a different set of participants. A participant was not asked to comment a second time unless a response was so out of phase with his contemporaries that it might be deemed as representing a potential breakthrough or simply an error. The first panel consisted of people working in the information-processing industry, while the second consisted of top experts from industry, government, and academia.

3. Each panelist was assigned work in those sub-categories in which he currently works. He was permitted to comment on and add events to other sub-categories where he had tangential interest. More weight was given to a panelist's comments in his area of expertise and proportionately less to comments in those sub-categories outside his normal work situation.

4. Specifically, two rounds were established as the finish of the DELPHI phase of this study. The panelists participating in both rounds were informed of the study plan prior to their involvement.

5. Event desirability (from the user's point of view) and event feasibility (from the producer's point of view) were specifically

addressed. Each event (whether originating in the sample, Round I, or Round II) has received this same type of evaluation.

6. Round II included an effort to identify major events and supporting events. Each Round II panelist segregated these supporting events into two categories: desirable and necessary. This process has permitted NAVSUP to identify a "menu" of potential short-, mid-, and long-range goals in information-processing technology, as well as alternative pathways (through supporting events) to make these goals achievable.

NAVSUP feels that the effort was successful to an appreciable degree in overcoming these first six shortcomings. However, the basic thesis of DELPHI and any of its mutations (e.g., TRW's "Probe" or NAVSUP's SEER) precludes the direct answering of the seventh drawback. The potential spur to idea generation made possible my personal contact is a valuable element lost in the trade-off for anonimity. Perhaps the best answer is to follow SEER's Round II with a series of seminar discussions between Round II panel members, utilizing the Round II data bank as a point of departure. Such a face-to-face confrontation would permit the accrual of almost all potential advantages SEER currently offers, with the added benefit of a fully-prepared, well-structured panel series. Consideration is currently being given to such a follow-up effort.

In conclusion, it can be stated that positive results were achieved by the use of the SEER technique. It permitted the forecasting organization to utilize the information being generated by an industry in which it had little influence and no control over trends. The application of SEER has identified alternatives in a sufficiently clear and complete manner to

facilitate executive decision-making. NAVSUP planning, as influenced by technological developments in the area of information-processing, is being modified based on the SEER forecast. New resource allocations will be affected by the results of the study.

Appendix A

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Government

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Department of the Navy, Office of the Special Assistant to the Secretary of the Navy
Federal Communications Commission
General Services Administration, National Archives and Record Services
National Bureau of Standards
National Security Agency
National Science Foundation
Office of the Director of Defense, Research and Engineering
Social Security Administration

Academic

Carnegie-Mellon University
Case Western University
Duke University
The George Washington University
Massachusetts Institute of Technology
University of California, Lawrence Radiation Laboratory
University of California, Los Angeles
University of Illinois
University of Pennsylvania, The Moore School of Electrical Engineering

Industrial

Adage, Inc.
Addressograph-Multigraph Corp.
Alden Electronic and Impulse Recording Equipment Co., Inc.
American Telephone and Telegraph
Amp, Inc.
Ampex Corp.
Auerbach Corp.
Astrodata Corp.
Beta Instrument Corp.
The Bunker-Ramo Corp.
Burroughs Corp.
Calma Co.
Carson Labs.
Comcor, Inc.

Computer Associates, Inc.
Computer Command & Control Co.
Computer Industries, Co.
Computer Sciences Corp.
Consolidated Electrodynamics Corp.
Control Data Corp.
Control Data - Rabinow
Core Memories, Inc.
Dasa Corp.
Datmec (Div. of Hewlett-Packard)
Data Disc, Inc.
Data Products Corp.
Digitronics Corp.
Eastman Kodak
Electronic Assoc., Inc.
Electro-Mechanical Res., Inc.
Fabri-Tek, Inc.
Farrington Corp.
Ferrox Cube Corp.
Frieden
General Electric Co.
General Inst. Corp. (Div. of Magna Head)
General Precision, Inc.
Hobbs Associates
Honeywell, EDP Div.
Honeywell, 3C Div.
Hewlett Packard
Houston Fearless Corp.
Hughes Aircraft
International Business Machines Corp.
Informatics
Information Displays, Inc.
Itek
ITT Data Systems
ITT Gilfilan, Inc.
Kennedy Co.
Leasco Data Systems, Inc.
Litton Industries
Magnavox
McDonnel Douglas
Memory Technology
Micromation Technology Corp.
Milgo Electronic Corp.
3M Co.
Mohawk-Data Sciences Corp.
National Cash Register
National Microfilm Association
Philco-Ford Corp.
Potter Inst. Co., Inc.
Radiation, Inc.
Raytheon Computer

RCA, EDP Division
Rixon Elec., Inc.
Sanders Assoc., Inc.
Stromberg-Carlson
Synnoetic Systems
Systems Applications and Software
System Development Corp.
Tally Corp.
Tally/Dartex
Tasker
Teletype Corp.
Univac
Uptime Corp.
Western Union
Xerox Corp.
Yerks-Wolf Associates, Inc.

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